QK1
.A237
v.23
1914/20

TRANSACTIONS

OF

THE ACADEMY OF SCIENCE OF ST. LOUIS

Vol. XXIII.

JANUARY, 1914 TO FEBRUARY, 1920

PUBLISHED UNDER DIRECTION
OF THE COUNCIL

ST. LOUIS.
NIXON-JONES PRINTING CO.

MISSOURI BOTANICAL
RECEIVED
APR 28 1921
GARDEN LIBRARY

CONTENTS.

PAGE.

TABLE OF CONTENTS..... iii

LIST OF OFFICERS..... v

LIST OF MEMBERS. Revised to February 28, 1920..... vi

1. PATRONS.
2. HONORARY MEMBERS.
3. ACTIVE MEMBERS.

PAPERS PUBLISHED. January 1, 1914, to February 28, 1920:

1. PHIL RAU AND NELLIE RAU.—Longevity in Saturniid Moths and Its Relation to the Function of Reproduction.—Plates I-V.—Issued December 22, 1914 1
2. MARY J. KLEM.—The History of Science in St. Louis.—Issued December 29, 1914..... 79
3. WILLIAM TRELEASE.—The Agaveae of Guatemala. —Plates VI-XXXV.—Issued July 15, 1916.. 129
4. FRANCIS E. NIPHER.—Disturbances Impressed upon the Earth's Magnetic Field.—Gravitation and Electrical Action.—Plates XXXVI-XLIV.—Issued July 28, 1916..... 153
5. FRANCIS E. NIPHER.—Gravitational Repulsion.—Plates XLV-XLVII.—Issued November 8, 1917 177
6. FRANCIS E. NIPHER.—Graphical Algebra Involving Functions of the Nth Degree.—Issued May 9, 1918..... 193
7. FRANCIS E. NIPHER.—Graphical Algebra.—Issued January 23, 1919..... 205
8. HARRY HARRIS.—Birds of the Kansas City Region.—Issued February 27, 1919..... 213
9. FRANCIS E. NIPHER.—A Study of the Properties of Integral Numbers.—New Evidence of a Relation Between Gravitation and Electrical Action and of Local Changes in the Electrical Potential of the Earth.—Issued March 2, 1920 372

CORRECTIONS.

Page 208.—In lines 2, 5, and 18 from bottom, for 1,593,125 read 1,953,125.

Academy of Science of St. Louis

LIST OF OFFICERS, 1920

PRESIDENT.....G. T. Moore

FIRST VICE PRESIDENT.....F. E. Nipher

SECOND VICE PRESIDENT.....Leo Loeb

RECORDING SECRETARY.....A. G. Pohlman

CORRESPONDING SECRETARY.....J. I. Shannon

TREASURER.....H. E. Wiedemann

LIBRARIAN.....R. J. Terry

CURATORS.....H. C. Irish, Hermann von Schrenk, C. H. Turner

DIRECTORS.....W. E. Shahan, H. M. Whelpley

MEMBERS

1. Patrons

Bixby, William K. .....Kingshighway and Lindell Blvd.
Mallinckrodt, Edward.....16 Westmoreland Pl.
McMillan, William N.....Century Bldg.

2. Honorary Members

Arrhenius, Svante.....University of Stockholm,
Stockholm, Sweden.
Bahlsen, Leopold.....University of Berlin,
Berlin, Germany.
Kitasato, Shibasaburo.....University of Tokyo,
Tokyo, Japan.
Lewald, Theodor..... Berlin, Germany.
Limburg, Stirum..... Berlin, Germany.
Orth, Johann.....University of Berlin,
Berlin, Germany.
Ostwald, Wilhelm.....University of Leipzig,
Leipzig, Germany.
Rutherford, Ernst.....University of Manchester,
Manchester, England.
Springer, Frank.....U. S. National Museum,
Washington, D. C.
Trelease, William.....University of Illinois,
Urbana, Ill.
Waldeyer, Wilhelm .....University of Berlin,
Berlin, Germany.
Wassermann, A.....University of Berlin,
Berlin, Germany.
Wittmack, L. .....University of Berlin,
Berlin, Germany.

3. Active Members

Alleman, Gellert[1] ..... Swarthmore College,
Swarthmore, Penn.
Allen, George L ..... 26 Westmoreland Pl.
Alt, Adolf ..... 5614 Waterman Ave.
Altheimer, Benjamin[1] ..... 25 Broad St., New York City.
Baldwin, F. A. ..... Wesleyan Hospital,
Kansas City, Mo.
Baumgarten, Walter ..... Humboldt Bldg.
Blair, Vilray P ..... Metropolitan Bldg.
Bock, George W ..... 2904 Allen Ave.
Bostwick, Arthur E ..... 14 North Kingshighway.
Brennan, Martin S ..... 6304 Minnesota Ave.
Brookings, Robert S ..... 6510 Ellenwood Ave.
Buehler, H. A.[1] ..... Rolla, Mo.
Burg, William ..... 5607 Waterman Ave.
Busch, Aug. A ..... Grant's Farm, Mo.
Bush, Benjamin F.[1] ..... Courtney, Mo.
Carpenter, George O ..... 12 Portland Pl.
Carr, C. Y. ..... 204 North Third St.
Carver, George W.[1] ..... Tuskegee, Ala.
Caspari, Charles E ..... 4060 Westminster Pl.
Chappell, W. G ..... 501 Clara Ave.
Chauvenet, William M. ..... 620 Chestnut St.
Clark, Enos ..... Kirkwood, Mo.
Clopton, Malvern B ..... Humboldt Bldg.
Colnon, R. S ..... 6417 Columbia Ave.
Conzelman, Theophilus ..... 5260 Washington Boul.
Cook, Isaac T. ..... Wright Bldg.
Cook, Jerome E ..... 5389 Pershing Ave.
Crunden, Frank P. ..... 4426 Westminster Pl.
Dana, Leslie ..... 1 Brentmoor Park.
Danforth, Charles H ..... Washington University
Medical School.
Drushel, J. A ..... Harris Teachers' College.

[1] Non-resident.

Duggar, Benjamin M.....Missouri Botanical Garden.
Duncker, Charles H.....Brentmoor Park.
Ebeling, A. W.[1].....Warrenton, Mo.
Eberle, E. G.[1].....Bourse Bldg.,
Philadelphia, Penn.
Eilers, Roy M.....Central National Bank Bldg.
Eimbeck, August F.[1].....New Haven, Mo.
Eliot, Edward C.....5468 Maple Ave.
Emerson, John B.....Syndicate Trust Bldg.
Erker, Adolph P.....608 Olive St.
Ewers, A. F.....3411 Pestalozzi St.
Ewing, Arthur E.....5956 West Cabanne Pl.
Fischel, Walter.....5082 Westminster Pl.
Fleisher, Moyer S.[2].....5531 Berlin Ave.
Fordyce, John R.[1].....2223 Louisiana St.,
Little Rock, Ark.
Fordyce, Samuel W.....21 Washington Terrace.
French, George H.[1].....Carbondale, Ill.
Frerichs, Frederick W.....4320 Washington Boul.
Fry, Frank R.....4609 McPherson Ave.
Funk, H. A. .....4069a Hartford St.
Glasgow, Frank A.....3894 Washington Ave.
Gratz, Benjamin .....Rialto Bldg.
Greene, F. C., Jr.[1].....30 North Yorktown St.,
Tulsa, Okla.
Greenman, Jesse M.....Missouri Botanical Garden.
Grindon, Joseph.....4368 Enright Ave.
Gundelach, William J.....University Club Bldg.
Guy, William E.....10 Portland Pl.
Hall, Robert A.[1].....2317 Humboldt Ave.,
Minneapolis, Minn.
Hanson, Frank B. .....Washington University.
Herf, Oscar .....Pierce Bldg.
Hild, George A. .....International Bank.
Hoffman, Philip.....3657 Delmar Ave.
Hughes, Marc Ray.....Metropolitan Bldg.
Hume, H. Harold[1].....Glen St. Mary, Fla
Ilhardt, William K.....4836 Delmar Ave.,

---

[2]Associate.

Irish, Henry C.....Rock Hill and Big Bend Road, Webster Groves, Mo.
James, George O.....Washington University.
Jeffrey, F. J.[2].....Yeatman High School.
Johnson, Albert L.[1].....Mutual Life Insurance Bldg., Buffalo, N. Y.
Jones, Breckinridge.....45 Portland Pl.
Jones, Robert McK.....6 Westmoreland Pl.
Kammerer, Alfred L.....Tower Grove and Flad Aves.
Kessler, George E.....Security Bldg.
Kessler, J. J.....224 South Vandeventer Ave.
Kimball, W. G. .....18 Lennox Pl.
King, Goodman.....78 Vandeventer Pl.
Ladd, Harry[2].....4374 McPherson Ave.
Lang, George, Jr.....3718 Juniata St.
Langsdorf, Alexander S.....Washington University.
Larkin, E. H.....3600 North Broadway.
Laughlin, Julian[1].....Clayton, Mo.
Leavitt, Sherman[1].....Illinois College, Jacksonville, Ill.
Lewis, E. G.[1].....Atascadero, Cal.
Lichter, John J.....1740 Simpson Pl.
Loeb, Leo.....Washington University Medical School.
Luedde, William H.....Metropolitan Bldg.
Lukens, C. DeWitt.....4908 Laclede Ave.
Lyon, Montague.....5865 Cates Ave.
Mallinckrodt, Edward, Jr.....Mallinckrodt Chemical Works.
Mardorf, W. C.....2136 South Grand Ave.
Markham, George D.....4961 Pershing Ave.
Mauran, John L. .....Chemical Bldg.
McCulloch, Richard.....4394 Westminster Pl.
Mesker, Frank.....421 South Sixth St.
Mills, R. W.[1].....Webster Groves, Mo.
Moore, George T.....Missouri Botanical Garden.
Moore, Philip N.....Merchants' Laclede Bldg.
Moore, Robert.....61 Vandeventer Pl.
Mudd, Harvey G.....Humboldt Bldg.
Nagel, Charles.....Security Bldg.
Nasse, August.....2323 Lafayette Ave.

Nickell, R. F. .....Monsanto Chemical Works.
Nicolaus, Henry.....Ninth and Sidney Sts.
Nipher, Francis E.....Kirkwood, Mo.
Nolker, William H.....Fifteenth and Pine Sts.
O'Reilly, Andrew J.....2207 South Grand Ave.
O'Reilly, Robert J.....27 Washington Terrace.
Padberg, Aloys J.....3900a Easton Ave.
Palmer, Ernest J.[1].....321 South Allen St.,
Webb City, Mo.
Pammel, Louis H.[1].....Ames, Iowa.
Pantaleoni, Guido.....15 Lennox Pl.
Parker, George W. .....Railway Exchange Bldg.
Perkins, Albert T.....3869 Park Ave.
Pettus, Charles P.....33 Westmoreland Pl.
Pettus, W. H. H.....4373 Westminster Pl.
Pitzman, Julius.....6 Kingsbury Pl.
Pohlman, A. G. .....1402 South Grand Ave.
Priest, Henry S. .....Central National Bank Bldg.
Pyle, Lindley.....Washington University.
Rassieur, Leo.....Fourth and Market Sts.
Reber, H. Linton.....Kinloch Bldg.
Reber, Maximè.....La Salle Bldg.
Reed, George M.[1].....Cereal Investigations, B. P. I.,
Washington, D. C.
Robarts, Heber[1].....Belleville, Ill.
Roever, William H. .....Washington University.
Rolfs, Peter H.[1].....Gainesville, Fla.
Rosenwald, Lucian[1].....412 Delaware St.,
Kansas City, Mo.
Rowse, Edward C.....Chemical Bldg.
Ruf, Frank A.....1624 Pine St.
Ruder, Carl.....4056 Delmar Ave.
Sackett, C. H. .....Junior High School.
Sargent, Charles S.[1].....Jamaica Plain, Mass.
Saunders, William F. .....5562 Clemens Ave.
Scanlan, Philip C.....4450 Lindell Blvd.
Schlueter, Robert E.....Metropolitan Bldg.
Von Schrenk, Hermann.....Tower Grove and Flad Aves.
Schwarz, Ernest.....6310 Newstead Ave.

Schwarz, Frank.....1809 Lafayette Ave.
Schwarz, Henry.....440 North Newstead Ave.
Schwarz, Hermann.....720 Clark Ave.,
Webster Groves, Mo.
Schweyer, George.....4259 Blaine Ave.
See, Thomas J. J.[1].....Naval Observatory.
Mare Island, Cal.
Selby, Augustine D.[1].....Wooster, O.
Senter, Charles P.....1 Beverly Pl.
Shackleford, Ben G.....3632 Lafayette Ave.
Shaffer, Philip A.....Washington University
Medical School.
Shahan, William E.....1126 McCausland Ave.
Shannon, James I.....St. Louis University.
Shapleigh, John B.....Humboldt Bldg.
Shepley, John F.....53 Portland Pl.
Shimek, Bohumil [1].....Iowa City, Ia.
Simmons, E. C.....Ninth and Spruce Sts.
Skinner, C. H.[2].....Washington University.
Sluder, Greenfield.....3542 Washington Ave.
Smith, David S. H. .....4388 Westminster Pl.
Spencer, Selden P. .....2725 Washington Ave.
Stewart, Seymour.....5261 Washington Blvd.
Taussig, Albert E.....Metropolitan Bldg.
Terry, Robert J. .....Washington University
Medical School.
Thacher, Arthur.....5185 Lindell Blvd.
Timmerman, Arthur H.....6400 Plymouth Ave.
Toomey, T. Noxon.....11 Aberdeen Pl.
Turner, Charles H.....Sumner High School.
Tuttle, Daniel S.....74 Vandeventer Pl.
Van Ornum, John L. .....Washington University.
Walker, Kennett S. .....Pierce Bldg.
Walsh, Julius S.....Fourth and Pine Sts.
Watts, Millard F.....5740 Cabanne Pl.
Webber, E. N. .....400 Skinker Road.
Weichsel, Hans.....6400 Plymouth Ave.
Werner, E. E. .....Railway Exchange Bldg.
Wells, W. S.[1].....Ann Arbor, Mich.

Wheeler, H. A.....510 Pine St.
Whelpley, Henry M. .....2342 Albion Pl.
Whitaker, Edwards.....300 North Fourth St.
Widmann, Otto.....5105 Enright Ave.
Wiedemann, H. E.....Chemical Bldg.
Wiener, Meyer.....Carlton Bldg.
Wiggins, Charles.....23 Portland Pl.
Wislizenus, Frederick A.....6 Kingsbury Pl.
Wolfner, Henry L.....4563 Forest Park Blvd

Transactions of The Academy of Science of St. Louis

VOL. XXIII. No. 1

LONGEVITY IN SATURNIID MOTHS AND ITS RELATION TO THE FUNCTION OF REPRODUCTION

PHIL RAU AND NELLIE RAU

Issued December 22, 1914

LONGEVITY IN SATURNIID MOTHS AND ITS RELATION TO THE FUNCTION OF REPRODUCTION.*

PHIL RAU AND NELLIE RAU.

INTRODUCTION.

If Nature's aim in the animal world be the improvement of the races, she must have a frequently changing medium upon which to operate; if it be merely their perpetuation, she may be satisfied with a few well favored individuals which live a long time. The first hypothesis concentrates attention upon the welfare of the race, the second on the welfare of the individual. But the purposes of Nature seem two-fold, both perpetuation and improvement of the stock.

It is obvious that the improvement would best be accomplished by the production of the maximum number of young in connection with a brief duration of life, thus giving a large number of tender individuals for Natural Selection to play upon, and many generations in a brief period of time through which to effect changes. This plan, however, could not hold good for all the members of the earth's animal population, for it would not permit of the development of size, strength and high differentiation of organisms—all these factors pertaining to the individual welfare.

A momentary mental survey of the animal world will tell us that a marked correlation exists between the length of life of individuals and the reproductive functions[1] of the various species, although we cannot say off-

---

*Presented by title to The Academy of Science of St. Louis, November 2, 1914.

[1] Reproductive function includes brood-care.

hand which is the primary and which the secondary function, whether the length of life depends upon the rate of increase, or the rate of reproduction depends upon the length of the generations—in other words, whether approaching death incites reproduction, or reproduction causes death.

We desired to get at the principles of the duration of life from the standpoint of their efficiency for the perpetuation of the species. Hence we made an extensive study of the longevity of Saturniid moths, with a view to ascertaining just what relationship exists between the longevity and environment and the function of reproduction. These pages embody the results gleaned from the records kept of a large number of individuals of several species for a number of seasons, and from several localities.

The data are presented in the following sequence:[2]

INTRODUCTION.

LONGEVITY.

PHILOSAMIA CYNTHIA.
TELEA POLYPHEMUS.
CALLOSAMIA PROMETHEA.
SAMIA CALIFORNICA.
SAMIA CECROPIA.
DISCUSSION OF LONGEVITY.
LONGEVITY UNDER CONDITIONS OF LOWERED TEMPERATURE.

OVIPOSITION.

NUMBER OF EGGS CARRIED.
COMPLETENESS OF OVIPOSITION.
AGE WHEN FIRST EGGS WERE DEPOSITED.
AGE AT WHICH THE GREATEST NUMBER OF EGGS WERE DEPOSITED.
LAPSE OF TIME BETWEEN LAST OVIPOSITION AND DEATH.

PROPORTION OF SEXES.

THE PRIORITY OF MALE EMERGENCE.

THE FERTILITY OF SATURNIID EGGS IN RELATION TO THE MATING PERIOD.
INTRODUCTORY REMARKS.
SAMIA CECROPIA.

---

[2]Since it is not customary for the Academy to publish a table of contents of its articles, we hope that this syllabus may serve the purpose of locating each unit.

PHILOSAMIA CYNTHIA.
TELEA POLYPHEMUS.
SAMIA CALIFORNICA.
THE MINIMUM DURATION OF MATING IN RELATION TO FERTILITY.

THE PERIOD OF INCUBATION.
SAMIA CECROPIA.
TELEA POLYPHEMUS.
SAMIA CALIFORNICA.
PHILOSAMIA CYNTHIA.

MISCELLANEOUS DATA ON SATURNIID BIOLOGY.
BASILONIA IMPERIALIS.
PROBABLE TWO-BROODEDNESS OF T. POLYPHEMUS.
INFERTILITY OF POLYPHEMUS EGGS.
CROSSINGS.
EATING OF EGG-SHELLS BY T. POLYPHEMUS.
CALLOSAMIA PROMETHEA.
FLUFFY COCOONS OF S. CECROPIA.
DURATION OF PUPAL STAGE IN S. CECROPIA.
DURATION OF THE PERIOD OF COPULATION IN T. LUNA.
COCOON SPINNING.

SUMMARY.

GENERAL CONSIDERATIONS AND CONCLUSIONS.

In a previous paper[3] we have reviewed fully the theories which have been formulated to account for the duration of life. Finding the existing theories inadequate to account for the results of our experiments, we made some suggestions as to what observations should be carried on before one can philosophize on the meaning of the duration of life.

In the present work we have followed out some of the courses of investigation mentioned there. The material is similar, but in far greater numbers, and from a variety of localities. The technique is essentially the same. We must once more urge the reader to bear in mind that the Saturniid moths have aborted mouth parts, and at no time in the adult existence do they require or can they assimilate food. This factor renders these moths ideal material for such observations in so far as the duration

[3] Journ. Exp. Zool., 12: 179-204, 1912.

of their lives cannot possibly be influenced by insufficient or improper food. One might naturally suspect that the conditions of confinement would be a factor in curtailing or prolonging life, but all the functions seemed to proceed in so normal a manner that we have little reason to think that this is the case. Thus this material offers a very unusual opportunity of obtaining for this study an organism which passes through practically all of its development in its native habitat, unrestrained, and may finish its feeding and then may be brought together from various regions in the experimentor's laboratory. Many animals do not have this clearly defined boundary between adolescence and adulthood.

The groups of material used are as follows:[4]

		Year	Insects
Philosamia cynthia	Philadelphia	1913	208
Philosamia cynthia	New York	1913	151
Telea polyphemus	New York	1912	35
Telea polyphemus	St. Louis	1913	92
Telea polyphemus	Augusta, Ga.	1913	351
Telea polyphemus	Fall River, Mass.	1913	174
Telea polyphemus	Augusta (cellar)	1913	66
Callosamia promethea	Fall River, Mass.	1913	104
Samia Californica	Sonoma Co., Cal.	1912	12
Samia cecropia	River des Pêres (normal)	1913	220
Samia cecropia	River des Pêres (fluffy)	1913	74
Samia cecropia	South St. Louis	1913	142
Samia cecropia	New York	1913	110
Samia cecropia	Fall River, Mass.	1913	9
Samia cecropia	River des Pêres (cellar)	1913	42
Samia cecropia	South St. Louis (cellar)	1913	38
Samia cecropia	River des Pêres (house)	1912	69

These notes on longevity then were made on 17 lots of material comprising 1897 individuals. In addition to this, observations were made upon reproductive phenomena in their relation to longevity.

---

[4] This material was obtained from Mr. J. J. Wirz of Augusta, Ga., Mr. Norman S. Easton of Fall River, Mass., Mr. Jesse Lund of New York City, and Mr. George H. Hosenfeld of St. Louis.

Longevity.

In 1910-11, observations were made on the longevity of about 900 of these moths, and the mean duration of life of the different lots were assembled in Table 1 (*loc. cit.*, p. 183). In the present work more than twice this number were employed in the continued search for new factors influencing the length of life. In like manner we have brought together in the table below the means for all of the lots of material herein considered. This table will frequently be referred to. (See Table 1.)

Philosamia cynthia.

Two lots of Cynthia cocoons were obtained for this purpose, one lot from Philadelphia, which yielded 208 insects, and the other from New York City, which gave forth 151 adults in good condition for these observations. Table 2 below gives the details of the duration of life of the Philadelphia lot. The cocoons were shipped to St. Louis during the winter and kept out of doors until spring when they emerged between June 7 and 28. (See Table 2.)

Table 3 presents the details of the longevity of the New York lot. The cocoons arrived here during the winter, were likewise kept out of doors in the trees until spring, and 151 imagines emerged between May 30 and June 25. (See Table 3.)

In comparing Tables 2 and 3 we find the New York lot to be slightly the longer lived throughout. In these two tables we find practically no difference between the mated and unmated males, showing that here at least mating does not perceptibly alter the life of the male. Among the females, however, the unmated individuals lived longer than the mated ones. A comparison of all males with all females shows the females as a class to be longer lived.

TABLE 1.

Mean Duration of Life.

See Table	Lot	Year	Mated ♂'s	Unmated ♂'s	Mated ♀'s	Unmated ♀'s	All Mated Insects	All Unmated Insects	All ♂'s	All ♀'s	Whole Population
2	P. cynthia, Phila.	1913	5.56	5.56	6.72	7.16	6.12	5.97	5.56	6.86	6.53
3	P. cynthia, N. Y.	1913	6.61	6.59	7.20	7.48	6.90	7.04	6.60	7.37	6.99
4	T. polyphemus, St. L.	1913	....	8.70	....	10.51	....	....	8.70	10.51	9.59
5	T. polyphemus, N. Y.	1912	....	7.44	....	10.33	....	....	7.44	10.33	8.43
6	T. polyphemus, Augusta, Ga.	1913	8.33	8.05	6.00	10.24	7.55	9.07	8.06	10.02	9.03
7	T. polyphemus, Fall River, Mass.	1913	....	7.03	....	8.37	....	....	7.03	8.37	7.63
8	C. promethea, Fall River, Mass.	1913	....	5.47	7.00	8.13	....	....	5.47	8.04	6.73
9	S. Californica, California	1912	8.67	8.67	8.25	10.00	8.43	9.20	8.67	8.84	8.75
10	S. cecropia, River des Peres, St. L.	1913	10.59	9.45	8.90	10.29	9.73	9.90	9.77	9.93	9.86
11	S. cecropia, St. L. (fluffy)	1913	11.11	11.76	9.53	10.22	10.34	11.05	11.46	9.89	10.72
12	S. cecropia, South St. L.	1913	9.89	9.31	8.11	9.95	8.99	9.68	9.63	9.06	9.32
13	S. cecropia, N. Y.	1913	10.75	10.48	9.25	10.25	10.06	10.41	10.59	9.65	10.24
14	S. cecropia, Fall River, Mass.	1913	....	7.00	....	7.00	....	....	7.00	7.00	7.00
15	S. cecropia, River des Peres (cellar)	1913	....	14.78	....	10.83	....	....	14.78	10.83	12.52
16	S. cecropia, South St. L. (cellar)	1913	....	12.69	....	11.77	....	....	12.69	11.77	12.16
17	T. polyphemus, Augusta, Ga. (cellar)	1913	....	11.69	....	12.94	....	....	11.69	12.94	12.33
18	S. cecropia, River des Peres (house)	1912	....	14.85	....	16.96	....	....	14.85	16.96	15.74

TABLE 2.

P. cynthia. *Philadelphia, Pa., 1913.*

Class	Days									Total	Mean
	3	4	5	6	7	8	9	10	11		
Mated ♂'s	..	6	30	9	7	5	..	..	..	57	5.56
Unmated ♂'s	1	22	12	16	15	6	..	..	..	72	5.56
Mated ♀'s	..	1	7	17	14	11	4	..	..	54	6.72
Unmated ♀'s	1	1	1	5	6	6	4	..	1	25	7.16
All Mated Insects	..	7	37	26	21	16	4	..	..	111	6.12
All Unmated Insects	2	23	13	21	21	12	4	..	1	97	5.97
All ♂'s	1	28	42	25	22	11	..	..	..	129	5.56
All ♀'s	1	2	8	22	20	17	8	..	1	79	6.86
Whole Population	2	30	50	47	42	28	8	..	1	208	6.53

TABLE 3.

P. cynthia. *New York, 1913.*

Class	Days													Total	Mean
	3	4	5	6	7	8	9	10	11	12	13	14	15		
Mated ♂'s	..	1	8	7	4	8	3	..	..	..	..	..	..	31	6.61
Unmated ♂'s	2	7	8	3	8	6	7	2	1	..	..	..	..	44	6.59
Mated ♀'s	..	..	3	7	11	5	3	..	..	..	..	..	1	30	7.20
Unmated ♀'s	..	..	4	14	10	8	4	1	3	1	..	..	1	46	7.48
All Mated Insects	..	1	11	14	15	13	6	..	..	..	..	..	1	61	6.90
All Unmated Insects	2	7	12	17	18	14	11	3	4	1	..	..	1	90	7.04
All ♂'s	2	8	16	10	12	14	10	2	1	..	..	..	..	75	6.60
All ♀'s	..	..	7	21	21	13	7	1	3	1	..	..	2	76	7.37
Whole Population	2	8	23	31	33	27	17	3	4	1	..	..	2	151	6.99

TELEA POLYPHEMUS.

In 1911 observations were made on 19 moths of this species from St. Louis. These all remained unmated. The females exceeded the males in length of life by almost 4 days. This year we have material of this species in larger numbers and from four localities, St. Louis, New York, Augusta, Ga., and Fall River, Mass. So much similarity exists in these that it will be well to present the four tables together for ready comparison. (See Tables 4, 5, 6 and 7.)

It is to be regretted that the Polyphemus material from every locality could not be induced to mate in sufficient numbers to be of any value. Every precaution was taken to offer them one or many mates of various ages, but despite this we succeeded in getting longevity data on only 9 mated moths out of a total of 718 insects.

The cocoons were in all cases shipped to St. Louis during the winter months. The St. Louis, New York and Massachusetts lots were kept out of doors exposed to the normal weather conditions of St. Louis until almost the time when they were expected to emerge. The Georgia cocoons were allowed to remain in the house, in an upstairs room of varying temperature but unheated for the most part.

Some variation occurred in the dates of emergence of the different lots. Those from St. Louis emerged between April 24 and May 15; those from New York, May 17-30; from Georgia, May 2-June 28, and from Massachusetts, May 1-June 25. We shall not presume here to explain the causes of these differences, but we shall only say that they must carry some significance in showing that the date of emergence is not wholly dependent upon environmental conditions at the time of emerging, for these four lots were all under the same conditions at that time, but that the larval conditions must in some way

TABLE 4.

T. polyphemus. *St. Louis, Mo., 1913.*

Class	Days												Total	Mean
	5	6	7	8	9	10	11	12	13	14	15	16		
Unmated ♂'s	4	4	7	11	5	4	5	4	2	1	..	..	47	8.70
Unmated ♀'s	1	4	1	6	7	3	4	7	3	7	1	1	45	10.51
Whole Population	5	8	8	17	12	7	9	11	5	8	1	1	92	9.59

TABLE 5.

T. polyphemus. *New York, 1912.*

Class	Days											Total	Mean
	4	5	6	7	8	9	10	11	12	13	14		
Unmated ♂'s	1	7	1	3	3	3	2	2	1	..	..	23	7.44
Unmated ♀'s	..	1	..	1	1	1	1	2	3	1	1	12	10.33
Whole Population	1	8	1	4	4	4	3	4	4	1	1	35	8.43

TABLE 6.

T. polyphemus. *Augusta, Ga., 1913.*

Class	Days																Total	Mean
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
Mated ♂'s	..	..	..	1	1	2	1	..	..	..	..	..	..	..	..	1	6	8.33
Unmated ♂'s	1	5	8	13	24	23	24	35	23	14	9	1	3	..	..	..	183	8.05
Mated ♀'s	..	..	..	2	..	..	1	..	..	..	..	..	..	..	..	..	3	6.00
Unmated ♀'s	..	2	4	3	4	8	19	21	24	19	23	15	8	6	3	..	159	10.24
All Mated Insects	..	..	..	3	1	2	2	..	..	..	..	..	..	..	..	1	9	7.55
All Unmated Insects	1	7	12	16	28	31	43	56	47	33	32	16	11	6	3	..	342	9.07
All ♂'s	1	5	8	14	25	25	25	35	23	14	9	1	3	..	..	1	189	8.06
All ♀'s	..	2	4	5	4	8	20	21	24	19	23	15	8	6	3	..	162	10.02
Whole Population	1	7	12	19	29	33	45	56	47	33	32	16	11	6	3	1	351	9.03

TABLE 7.

T. polyphemus. *Fall River, Mass., 1913.*

Class	Days													Total	Mean
	3	4	5	6	7	8	9	10	11	12	13	14	15		
Unmated ♂'s	1	5	16	19	25	9	9	7	2	2	..	1	..	96	7.03
Unmated ♀'s	3	1	7	8	12	14	7	9	7	5	..	4	1	78	8.37
Whole Population	4	6	23	27	37	23	16	16	9	7	..	5	1	174	7.63

contribute something toward determining the duration of pupal life.

In Polyphemus, the two southern localities yielded material of longer life than the two northern ones. May not this be considered a natural consequence of the animals having favorable conditions of growth and abundant supply of food in their developmental stages? Or should it be considered an indication that up north the tendency is toward going through the life cycle and reproduction in a lessened period?

Comparing now the tabulated summaries of the data on these four lots of Polyphemus from as many widely remote localities, we find that in absolutely every case the mean duration of life in the unmated females exceeds that of the males by 1.34 to 2.89 days. We must realize, of course, that every hour counts much in the life of one of these frail creatures, and that even this brief time represents approximately 20% of their normal lifetime. We may well disregard the 9 mated individuals in the Georgia lot, since their number is inadequate to be reliable for any conclusions.

It does indeed set one a-searching for reasons and explanations—to find that this condition of greater life of the female should exist in *every* lot of this material, each lot from a region far remote from the other, but this condition or character must exist in Polyphemus' nature, and must be a specific part of them as much as any anatomical character. We feel that these conclusions may be considered reliable, since they are based upon the evidence from so great a number of insects.

In comparing the mean duration of life of the entire population of these five lots, we find some divergence, in fact, great divergence when we consider what time means to these creatures. The St. Louis 1913 Polyphemus were the longest lived, with the mean for the whole population at 9.59 days. The Augusta material ranked next with a mean duration at 9.03 days; the New York

followed with a like mean of 8.43 days and the Fall River lot brought the lowest mean of 7.63 days.

This divergence invites investigation. Does the climate under which the larva lives, or the food supply, or the shorter or longer period in the larval stage (due to approaching cold or diminishing food supply), do any or all of these things affect the adult life? All of the animals had fed in their native haunts; all had passed through the entire formative period of their lives under unrestricted, natural conditions of their own habitat; when they came to us they were in the quiescent stage, waiting for the warm days of spring to emerge; nourishment could no longer be a factor in their lives. If the St. Louis climate affected the strangers in so marked a degree, why were not all affected alike?

This points to new fields of investigation. Herein lies excellent opportunity for ascertaining the causes of lengthened or shortened adult life; whether it be a specific trait or in how far it is merely the result of individual environment; and, if a specific character, whether it can be made to vary as such or can be permanently altered for the race by artificial conditions. It would be well if such work could be done from year to year, at localities remote from one another, individual records in large numbers accumulated, the place mode found and these compared with the climatic and other conditions.

CALLOSAMIA PROMETHEA.

In 1911 we obtained notes on the longevity of 170 insects of this species from the Crêve Coeur region, St. Louis. Here we found that the unmated males lived longer than the mated males, and likewise the unmated females exceeded the mated females, and that the females, all taken together as a class, lived longer than the males.

In a lot of cocoons of this species received from Fall River in 1913, 104 insects emerged between May 19 and

June 17, all of which were used in this investigation. (See Table 8.)

The table shows that they were extremely reticent about mating in confinement. All our efforts to offer the best opportunities brought successful results in the case of only four females, and even these rejected the males of their own species and mated with Cynthias. This table also shows that the unmated females were much longer lived than the males and also than the mated females, just as they were in the 1911 material, but as a whole the duration of life was much greater in the 1913 Fall River material than in the 1911 Crêve Coeur lot. Comparing in greater detail these two lots from different localities and years, we find the mean for the males to be greater in the former lot by 1½ days, and for the females by an excess of 2 days. Only consider the meaning of 2 days in the life of an insect, the duration of whose life is from 2 to 12 days.

It is indeed perplexing when we find that the Polyphemus from Massachusetts showed a mean much lower than did those from St. Louis, and that the Prometheas from there had a mean duration much greater than those from this region.

SAMIA CALIFORNICA.

Out of a large number of cocoons from Sonoma Co., California, only 14 insects emerged. Of these, 12 could be used for longevity work. (See Table 9.)

The table shows that they lived from 7 to 12 days, the mean for the entire population being 8.75 days. It is much regretted that the number available for this study is insufficient for the much desired comparisons, although it is interesting to note that these few give evidence of the same tendencies as the other species thus far considered in that the female sex and the unmated condition both tended toward longer life.

TABLE 8.

C. promethea. *Fall River, Mass., 1913.*

Class	Days											Total	Mean
	2	3	4	5	6	7	8	9	10	11	12		
Unmated ♂'s	1	4	12	12	10	7	5	1	1	..	..	53	5.47
Unmated ♀'s	..	..	..	8	8	3	4	9	8	4	3	47	8.13
Mated ♀'s	..	..	..	1	1	..	1	1	..	..	..	4	7.00
All ♀'s	..	..	..	9	9	3	5	10	8	4	3	51	8.04
Whole Population	1	4	12	21	19	10	10	11	9	4	3	104	6.73

TABLE 9.

S. Californica. *Sonoma Co., Cal., 1912*

Class	Days						Total	Mean
	7	8	9	10	11	12		
Mated ♂'s	2	...	...	...	...	1	3	8.67
Unmated ♂'s	1	...	1	1	...	...	3	8.67
Mated ♀'s	1	1	2	...	...	...	4	8.25
Unmated ♀'s	...	...	...	2	...	...	2	10.00
All Mated Insects	3	1	2	...	...	1	7	8.43
All Unmated Insects	1	...	1	3	...	...	5	9.20
All ♂'s	3	...	1	1	...	1	6	8.67
All ♀'s	1	1	2	2	...	...	6	8.84
Whole Population	4	1	3	3	...	1	12	8.75

SAMIA CECROPIA.

In the paper already referred to we paid most attention to the Cecropia moth, chiefly because this species could be procured in greatest numbers. In this paper we deal with five additional lots of this material under normal conditions, and three lots (controls) which will be taken up in detail later. The five lots are as follows:

River des Pêres (St. Louis) normal cocoons.
River des Pêres fluffy cocoons.
South St. Louis cocoons.
New York cocoons.
Fall River cocoons.

Before going into the details of this work, it may be well to give a brief resumé of the previous experiments.

The River des Pêres Cecropia population emerging in the spring of 1910 split up into two distinct lots; all of the moths which emerged early, April 13 to May 14, lived long lives (the mean for this portion of the population was 16.65 days), while all of those which emerged late in the season, May 14 to June 17, lived short lives (the mean for this group being 10.14 days). In 1911 this splitting up did not occur, but the three lots of material known as the St. Louis Cecropias 1911, the New York Cecropias 1911, and the Incubator Cecropias 1911, gave a mean duration of life of 7.71 days, 8.06 and 8.00 days respectively. This gave a clue to the following hypothetical explanation. The 1910 material began to emerge in April, a month earlier than usual. This abnormally early emergence was perhaps due to the exceptionally warm month of March, and when the unusually cold weather followed in April the animals lived noticeably longer than usual. It was thought that the cold was directly responsible for this long life since they were numb and remained quite inactive, and hence expended little or none of their reserve energy, and that those moths which emerged later found the weather warm and

inviting to activity, and in due time expended their quota of stored nourishment and died after the normal length of life. Further experiments, keeping adult moths in an ice-box, proved that cold markedly lengthens their life.

We have then already stated that the mean duration of life of the Cecropia moth was shorter in 1911 than in 1910; this may be correlated with the fact that the period in which they lived was warmer in 1911. A comparison of Table 8 with Table 1 (*loc. cit.*, pp. 192 and 183), shows that in every case a variation in the length of life accords with a simultaneous variation in temperature.

Now we come to the data of the 1913 Cecropia work. The St. Louis Cecropias known as the River des Pêres lot were gathered from the same area, near Forest Park, as in previous years. This time they were sorted into two lots, one containing all of the normal cocoons, and the other the loosely woven or fluffy cocoons.[5] 336 insects emerged from the normal cocoons between May 9 and June 16, 220 of which were used for longevity data. (See Table 10.)

Here again the mean duration of life was greater for the mated males than the unmated males and *vice versa* for the females. To be sure the mean length of life is almost equal for the two classes, "all mated" and "all unmated" insects, and also the groups "all males" and "all females," but this equality is probably of little significance since it results merely from the counterbalancing of the more significant numbers just referred to. The mean length of life for this whole population was 9.86 days.

Of the 79 insects which emerged from the fluffy cocoons between May 5 and June 12, 74 were used for longevity notes. (See Table 11.)

---

[5] These were sorted out and treated separately for the purpose of continuing the study (see Psyche, 18: 168-170, 1911) of this fluffy condition to ascertain whether it is hereditary, and whether other differences, such as longevity, oviposition, etc., make them distinctly different from normal cocooned insects.

TABLE 10.

S. cecropia. *St. Louis, River des Peres, 1913.*

Class	Days																			Total	Mean
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Mated ♂'s	..	..	..	..	1	2	4	4	3	4	4	3	2	2	..	..	..	..	..	..	29	10.59
Unmated ♂'s	..	..	1	6	2	9	7	13	12	12	4	4	1	3	1	..	..	..	..	..	75	9.45
Mated ♀'s	..	..	..	..	5	5	4	7	2	3	3	..	..	..	..	..	1	..	..	..	30	8.90
Unmated ♀'s	1	3	..	3	4	10	3	12	7	9	12	5	6	9	..	1	..	..	..	1	86	10.29
All Mated Insects	..	..	..	..	6	7	8	11	5	7	7	3	2	2	..	..	1	..	..	..	59	9.73
All Unmated Insects	1	3	1	9	6	19	10	25	19	21	16	9	7	12	1	1	..	..	..	1	161	9.90
All ♂'s	..	..	1	6	3	11	11	17	15	16	8	7	3	5	1	..	..	..	..	..	104	9.77
All ♀'s	1	3	..	3	9	15	7	19	9	12	15	5	6	9	..	1	1	..	..	1	116	9.93
Whole Population	1	3	1	9	12	26	18	36	24	28	23	12	9	14	1	1	1	..	..	1	220	9.86

TABLE 11.

S. cecropia. *St. Louis, River des Peres, 1913, (fluffy).*

Class	Days																	Total	Mean
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20		
Mated ♂'s	1	..	..	2	2	..	..	2	1	1	5	..	2	1	1	..	..	18	11.11
Unmated ♂'s	..	..	..	1	1	1	..	2	7	2	3	..	1	2	..	..	1	21	11.76
Mated ♀'s	1	..	1	..	3	..	3	3	4	..	..	1	..	..	..	1	..	17	9.53
Unmated ♀'s	1	..	1	..	1	2	2	3	2	1	1	2	2	..	..	..	..	18	10.22
All Mated Insects	2	..	1	2	5	..	3	5	5	1	5	1	2	1	1	1	..	35	10.34
All Unmated Insects	1	..	1	1	2	3	2	5	9	3	4	2	3	2	..	..	1	39	11.05
All ♂'s	1	..	..	3	3	1	..	4	8	3	8	..	3	3	1	..	1	39	11.46
All ♀'s	2	..	2	..	4	2	5	6	6	1	1	3	2	..	..	1	..	35	9.89
Whole Population	3	..	2	3	7	3	5	10	14	4	9	3	5	3	1	1	1	74	10.72

In this table we see only a slight difference in the mean duration of life of the mated and unmated males, and in this case it is in favor of the unmated individuals; the same is true of the females. When we compare the mean for all females with that of all males, we are surprised to find a much greater difference, and strangely enough, this is in favor of the males. The mean duration of life for this entire lot coming from fluffy cocoons is 10.72 days, or nearly a day more than the normal moths of the same year and place. (See Table 10.) When we compare the figures for these two parts of the population, we see that the mean length of life is greater in the fluffy lot in practically every class. Why should it be so unless the insects in the large, fluffy cocoons are endowed with greater vigor or a greater supply of reserve energy which carries them just a little further in life? May it be that they are thus well supplied with reserve nutriment as a direct result of abundant food supply of these individuals in the larval stage, and that the spinning of the larger cocoons is likewise merely the outcome of this accelerated growth?

Our next lot of material is that known as the South St. Louis Cecropias. Of the 236 insects which emerged from these cocoons between May 7 and June 13, 142 furnished longevity data. (See Table 12.)

Here we find that the mean duration of life of the mated males was greater than that of the unmated ones, while just the reverse was true for the females, and here too the mean duration of life of all males taken together was greater than that of all females. The mean for the whole population, 9.32 days, is the lowest of the Cecropia lots taken up in this paper, but it is greater than some of the 1911 lots.

The New York Cecropia material consisted of 143 insects which emerged between May 1 and June 4, 110 of which were used for these tabulations. (See Table 13.)

In this group we find precisely the same relation of length of life to sex and mating as in the foregoing lot;

TABLE 12.

S. cecropia. *South St. Louis, 1913.*

Class	Days																	Total	Mean
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
Mated ♂'s	1	..	1	..	1	1	4	5	12	2	6	1	..	..	1	1	..	36	9.89
Unmated ♂'s	..	..	..	3	..	3	6	3	6	5	1	..	1	..	..	..	1	29	9.31
Mated ♀'s	..	..	3	1	3	7	8	5	5	3	2	..	..	..	..	..	..	37	8.11
Unmated ♀'s	1	..	..	2	4	..	3	7	5	5	6	4	2	..	..	..	1	40	9.95
All Mated Insects	1	..	4	1	4	8	12	10	17	5	8	1	..	..	1	1	..	73	8.99
All Unmated Insects	1	.	..	5	4	3	9	10	11	10	7	4	3	..	..	..	2	69	9.68
All ♂'s	1	..	1	3	1	4	10	8	18	7	7	1	1	..	1	1	1	65	9.63
All ♀'s	1	..	3	3	7	7	11	12	10	8	8	4	2	..	..	..	1	77	9.06
Whole Population	2	..	4	6	8	11	21	20	28	15	15	5	3	..	1	1	2	142	9.32

TABLE 13.

S. cecropia. *New York, 1913.*

Class	Days											Total	Mean
	5	6	7	8	9	10	11	12	13	14	15		
Mated ♂'s	..	1	1	3	2	6	2	7	4	2	..	28	10.75
Unmated ♂'s	1	1	3	..	8	10	5	6	5	1	2	42	10.48
Mated ♀'s	..	..	4	5	7	3	2	1	1	1	..	24	9.25
Unmated ♀'s	..	1	3	2	2	..	1	3	2	..	2	16	10.25
All Mated Insects	..	1	5	8	9	9	4	8	5	3	..	52	10.06
All Unmated Insects	1	2	6	2	10	10	6	9	7	1	4	58	10.41
All ♂'s	1	2	4	3	10	16	7	13	9	3	2	70	10.59
All ♀'s	..	1	7	7	9	3	3	4	3	1	2	40	9.65
Whole Population	1	3	11	10	19	19	10	17	12	4	4	110	10.24

TABLE 14.

S. cecropia. *Fall River, Mass., 1913.*

Class	Days								Total	Mean
	3	4	5	6	7	8	9	10		
Unmated ♂'s	..	1	..	1	1	1	..	1	5	7.00
Unmated ♀'s	..	1	..	1	..	1	..	1	4	7.00
Whole Population	..	2	..	2	1	2	..	2	9	7.00

in the males, the mated individuals survived longer and in the females the unmated ones. And again in comparing all males with all females we find the greater mean longevity in favor of the males.

The mean for the entire population is 10.24 days. This is greater than that of any other lot of Cecropias of this year excepting those from fluffy cocoons. Of course the length of life does not equal that of the lot in 1910 which emerged early and lived so much longer than usual on account of the peculiar weather conditions. It is very interesting to note that the mean longevity for this entire lot is much higher than that of the same species from the same locality only two years before (*loc. cit.*, p. 193). Inspection of these tables will show that in every case the mean duration was greater for the 1913 New York Cecropias by from 2 to 3 days.

From the Fall River lot of Cecropia cocoons only 9 moths were obtained. This material is insufficient to warrant comparisons. (See Table 14.)

DISCUSSION OF LONGEVITY.

To briefly summarize all of the Cecropia data in a comparative way, we should bring together the details of Table 1 of this paper with Table 1 of the former publication.

First we see that none of the Cecropia excepting the 1910 lot split up into distinct groups of early and late emerging, and long- and short-lived individuals. The reason why this phenomenon should stand alone and unrepeated in the subsequent collections was the unique weather conditions of that year, giving the extremely favorable climatic conditions in March, hastening their development to an early emergence, followed by an unusually cold April which caused them to live longer. But when we compare the means for the whole population of Cecropia moths in the various lots (see last column of

the tables), we find considerable variation, but all within the limits of 7.71 and 10.72 days.

What can be the cause of this variation in the length of life? Why, for instance, should the New York Cecropias show a mean life for the whole population in 1911 of 8.06 days, and in 1913 of 10.24 days? The difference may seem trivial in itself, but it is significant enough to assure us that there must be some potent factors, as yet undiscovered, working singly or together determining these conditions. How can we account for it unless it be that one crop of insects acquire more or another less food as larvae, or perhaps the succulence or the chemical composition of the food plants may vary from year to year, or a thousand fine adjustments in nature of which we are yet ignorant.

Comparing next the mean length of life of all males and all females, we find in two lots the duration of life of both sexes almost equal, and in seven lots[6] we find the mean for the males to be the greater. This shows that the male lives as long or even longer than the female. This is in direct contrast with what we have already observed in Polyphemus, where the male is much shorter lived.

Then again when we compare the means for all mated insects of both sexes with all unmated, we find that for every one of the nine lots the life was longer in the unmated groups, but which sex contributes most to this higher mean can be ascertained by inspecting the first four columns of the two tables. In considering the length of life of the mated and unmated males we find that in 8 of the 9 lots of Cecropias the mean duration of life was practically equal for the mated and unmated males. In only one case, the 1913 St. Louis Cecropias, do we find the life longer for the mated males, by a difference of 1.14 days. Thus we see that in this species copulation hardly

---

[6] Excluding the Fall River cecropias, which were insufficient in numbers to be reliable, and the ice-box cecropies, which were under artificial conditions.

affects the longevity of the male one way or the other, and hence we see that in the above discussion of the duration of life of all mated insects as compared with all unmated insects that the males contribute nothing, or at least very little, to the figures showing the unmated insects to be the longer lived. The responsibility of this significant difference must therefore devolve upon the females—a very worthy point. So if the males do not cause this swinging of the balance, a survey of the tables ought to show that the unmated females are longer lived than the mated females. And so it does. In absolutely every case we find the mean duration of life of the groups of unmated females to be the greater by a good margin.

Here we come to the problem: is the longevity of the virgin female the natural length of life, and is it cut short by mating, or is the life of the mated female the natural one, and without mating is it prolonged, as one might think, to give the individual a chance to mate? But since we see the unmated Polyphemus living a long period, would it be far-fetched to conclude that in the mated condition of the Cecropia the life is shortened? But whether or not this shortening or lengthening of life is of advantage to the species we leave for later discussion.

Since the male can be a vagrant and take license as he will and not have his number of days reckoned for him, and since it seems that the female must pay the price of complete living by forfeiture of some days of her life, it would be of interest to know precisely how such factors react upon organisms higher in the scale of life, say rats, poultry, sheep, etc., and from there it would be only a step to our own species.

LONGEVITY AND TEMPERATURE.

In 1910 when we suspected that low temperature tended to prolong the life of the early emerging insects, we placed a number of Cecropias in an ice-box, the tem-

perature of which varied from 9° to 12° C. Here we found that they attained the surprising maximum age of 32 days, while their contemporaries in ordinary conditions reached only 13 days.

Again this year we attempted similar experiments, but not in so rigorous a form. The material (two lots of Cecropias and one of Polyphemus) was placed in a cemented basement where the temperature was somewhat lower than the out-of-doors, and also considerably lower than the room where the other live material was kept. The three tables following give the details of the work. (See Table 15.)

By comparing these 42 insects with their contemporaries, the River des Pêres Cecropias, we find the mean duration of life considerably greater for those kept in the basement, and especially the males of the lot. The mean for the entire basement lot is greater than that for those kept in the ordinary living-room by 2.66 days.

From the South St. Louis lot of Cecropias, 38 were selected at random and placed in the cool basement. (See Table 16.)

In this lot the mean for the males and also for the whole population is somewhat lower than that for the River des Pêres basement material—a condition parallel with the parent stock. But here too we have a higher mean duration of life than for their contemporaries in the living-room. We find the cellar conditions prolonging the life of these 2.84 days over that of their fellows.

Sixty-six Polyphemus moths, selected at random from the Atlanta, Ga., material were subjected to the same treatment. (See Table 17.)

When we compare these with their contemporaries in the living-room (Table 6), we are again reminded of "not how long but how well one lives"; again the laws of compensation are revealed. These lethargic animals in the cellar lived longer than did those in the living-room by differences far greater than those recorded for the Cecropias,—*viz.*, the unmated Polyphemus males lived 3.64

TABLE 15.

S. cecropia. *River des Peres, St. Louis, 1913, (cellar lot).*

Class	Days															Total	Mean
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Unmated ♂'s	..	..	1	..	1	1	1	1	1	..	2	3	3	1	3	18	14.78
Unmated ♀'s	1	1	..	..	3	7	4	4	2	..	1	..	..	..	1	24	10.83
Whole Population	1	1	1	..	4	8	5	5	3	..	3	3	3	1	4	42	12.52

TABLE 16.

S. cecropia. *South St. Louis, 1913, (cellar lot).*

Class	Days															Total	Mean
	3	4	5-6	7	8	9	10	11	12	13	14	15	16	17	18-23	24		
Unmated ♂'s	1	..	..	..	..	2	..	2	3	1	2	..	4	1	..	..	16	12.69
Unmated ♀'s	..	1	..	1	2	..	3	4	2	2	3	2	1	..	..	1	22	11.77
Whole Population	1	1	..	1	2	2	3	6	5	3	5	2	5	1	..	1	38	12.16

TABLE 17.

T. polyphemus. *Augusta, Ga., 1913, (cellar lot).*

Class	Days																	Total	Mean
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
Unmated (all) ♂'s	2	..	1	2	1	6	5	..	5	3	4	1	2	..	..	..	..	32	11.69
Unmated (all) ♀'s	..	..	3	2	4	1	3	5	1	3	1	3	5	..	1	..	2	34	12.94
Whole Population	2	..	4	4	5	7	8	5	6	6	5	4	7	..	1	..	2	66	12.33

TABLE 18.

S. cecropia. *House lot, 1912.*

Class	Days																													Total	Mean
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34		
Males	1	.	1	.	2	1	4	5	3	3	1	3	2	4	1	..	1	1	..	4	..	..	1	..	..	1	..	..	..	..	1	40	14.85
Females	.	1	2	.	.	1	3	..	2	3	2	..	3	1	..	..	..	2	1	..	1	1	..	1	..	1	..	1	2	1	..	29	16.96
Whole Population	1	1	3	.	2	2	7	5	5	6	3	3	5	5	1	..	1	3	1	4	1	1	1	1	..	2	..	1	2	1	1	69	15.74

days longer in the basement than did those in the living-room, the females 2.70 days longer, and the whole population 3.30 days longer than their more energetic fellows.

In January and February 69 adult Cecropias emerged from cocoons gathered from the River des Pêres region and kept in a living-room which was slightly heated during the day, but almost always cool at night. The table shows the duration of life of these insects. (See Table 18.)

Some lived but a very short time, due perhaps to abnormalities or weakness resulting from their premature development and emergence, but for the most part they gave results comparable with the ice-box experiments of 1910 (*loc. cit.*, p. 190), and while the mean duration of life is not so great in all of these three lots, yet we found the maximum duration of life to be even greater than in the ice-box work.

Since these various conditions of lower temperature prolonged the lives of the insects considerably, and since the extreme conditions of the ice-box prolonged them extremely, one cannot evade the conclusion that temperature is a factor which to a great extent controls the length of life of these delicate organisms. It may be only a matter of delicate, refined technique (slowly and gradually lowering the temperature, with proper ventilation, etc.), that is needed to suspend metabolism and increase the longevity in these frail creatures to surprising extremes, since it seems principally a matter of conservation of energy until it is necessary for such energy to be expended. Such phenomena undoubtedly occur in the Lepidoptera which hibernate as imagines.

Oviposition.

NUMBER OF EGGS CARRIED.

The moths of the family Saturniidae here considered hibernate as pupae in silky cocoons. The caterpillars, heavy consumers of vegetation, stop feeding at a certain

period of their growth and spin these cocoons about themselves. After a very brief period in the cocoons the larvae transform into pupae. It is in this pupal stage that the development of the eggs occurs. When a female emerges as an adult, Nature has already prepared her for her brief life by having all of the eggs matured and ready for oviposition. In some of the longer-lived Lepidoptera, some of the eggs are being deposited while others are maturing. Here, however, the eggs are all ready to be laid when the insect emerges from the cocoon, and when these are laid, or sometimes before all are deposited, she dies. With conditions such as these it is easy to tell precisely the total number of eggs carried by each individual.[7] Of course, we assume that the total number of eggs carried by each female is influenced by the home conditions of the larva, that is, food, climate and moisture, and that the local conditions of the last few months of pupal life, spent at St. Louis, could not in any way influence the number of its eggs.

During 1911-13 we made a study of the eggs carried by the 504 individuals of 19 lots of these moths. (See Table 19.)

For convenience the numbers of eggs carried were thrown into groups of twenty, but the averages in the last column were reckoned from the actual numbers. The table gives some interesting comparative details. For the five lots of Polyphemus material the means vary from 198 to 293 eggs. The mean number of eggs carried by the Fall River Polyphemus of 1913 equaled that of St. Louis for the same year. The St. Louis lot for 1911 had the largest average while the New York 1912 lot ranked second, but for the last two the numbers of observations were small, and one must be cautious not to lay too much weight upon this evidence. The Polyphemus from Augusta, Ga., had the smallest average number of eggs, 198.

---

[7] This is done by adding the number of ova deposited to the number retained as revealed by dissection after death.

TABLE 19.

The Number of Eggs Carried at Emerging.

Class	0- 20	21- 40	41- 60	61- 80	81-100	101-120	121-140	141-160	161-180	181-200	201-220	221-240	241-260	261-280	281-300	301-320	321-340	341-360	361-380	381-400	401-420	421-440	441-460	Total	Mean
Polyphemus, St. L. 1911	..	..	..	..	..	..	..	..	..	..	..	..	1	1	2	1	2	..	..	..	..	..	..	7	293
Polyphemus, N. Y. 1912	..	..	..	..	1	..	1	1	..	1	..	..	1	2	2	..	2	1	..	..	..	..	..	12	245
Polyphemus, St. L. 1913	..	..	1	1	2	..	5	1	3	3	4	5	9	3	3	2	2	1	..	..	..	..	..	45	216
Polyphemus, Mass. 1913	..	..	..	1	..	3	1	5	3	5	5	3	6	2	1	2	3	1	..	1	..	..	..	42	218
Polyphemus, Ga. 1913	..	1	1	1	..	1	2	5	3	3	3	4	5	2	..	2	..	..	..	..	1	..	..	34	198
Cecropia, St. Louis .....[8]1910	..	..	..	..	..	..	..	..	..	..	2	..	6	4	3	8	8	5	9	4	1	8	6	64	344
Cecropia, St. Louis 1912	..	..	..	..	..	..	..	..	3	2	5	2	1	2	2	6	..	2	1	1	..	..	..	27	262
Cecropia, St. Louis 1913	..	..	..	..	..	..	..	3	1	2	..	2	3	4	4	5	2	2	3	1	1	..	1	34	285
Cecropia, St. L. (fluffy) 1913	..	..	..	..	..	..	..	..	2	..	1	..	1	..	1	4	1	2	1	3	1	1	2	20	332
Cecropia, South St. L. 1913	..	..	..	..	..	..	1	..	..	..	1	..	3	3	1	2	1	1	1	..	..	..	..	14	282
Cecropia, N. Y. 1913	..	..	..	..	..	..	..	2	..	..	1	1	2	1	2	5	3	1	2	..	1	..	..	21	290
Promethea, Creve Coeur.....1911	1	..	1	2	1	3	2	1	3	9	8	3	2	7	1	2	..	..	..	..	..	..	..	46	195
Promethea, Mass. 1913	..	..	..	2	1	2	3	6	5	1	6	3	2	2	1	..	..	1	..	1	..	..	..	36	190
Luna, St. L. 1911	..	2	..	4	2	..	..	..	1	1	..	..	..	..	..	..	1	..	..	..	..	..	..	11	111
Luna, Pike Co. 1911	..	..	..	1	..	..	2	1	1	..	1	2	1	1	1	..	1	..	..	..	..	..	..	12	203
Californica, Cal. 1912	..	..	..	..	..	..	..	..	..	..	..	1	2	..	1	1	..	..	..	..	..	..	..	5	266
Cynthia, N. Y. 1912	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	1	1	..	..	1	1	6	374
Cynthia, N. Y. 1913	..	..	..	..	..	..	..	..	..	2	2	3	5	3	4	4	6	4	4	2	2	3	..	44	312
Cynthia, Phila. 1913	..	..	..	..	..	..	..	..	..	1	1	2	..	1	1	1	3	6	4	3	1	..	..	24	327

[8] These data published in Trans. Acad. Sci., St. Louis, 20: 315-316, 1911.

One would think that the semi-tropical conditions of Georgia, with an abundance of vegetation through a longer feeding season than at St. Louis or Fall River, would stimulate the production of eggs far to exceed those from the northern localities.

In considering the six lots of Cecropia material we have not so wide a range in their means, 262 to 344 eggs. The River des Pêres lots alone show a fluctuation from year to year of 344, 262 and 285 eggs. It is interesting to note that the South St. Louis material gathered in 1913 from an area two or three miles distant from the River des Pêres region should show an average practically equal (282) for the same year, while the mean for the New York lot of that year also, 290, is strikingly similar.

The females from the large, fluffy cocoons culled from the 1913 River des Pêres lot show a much higher average number of eggs (332) than the normal stock, or than the Cecropias of any other place or year excepting the 1910 lot. This point, added to the fact of the greater length of life, certainly leaves one with the conviction that these animals are more favorably endowed than their fellows, and will increase more rapidly than the remainder of the population, if not checked by other factors.

We can hardly speculate upon the significance of these details. We do not know what influences are to be reckoned with in the determination of egg production. We must wait for experimental research to tell us whether the number of ova produced is in any way correlated with the nutrition of the animal during the developmental period.

The Prometheas from St. Louis in 1911 and those from Fall River in 1913 show but very little difference in the average number of eggs carried (195 and 190 respectively), despite the fact that the two localities are extremely remote.

The two small lots of Lunas, one from St. Louis and the other from Pike Co., Mo., differ widely in the mean number of eggs carried, but the small number of the St. Louis lot may be attributed to the fact that they were bred in confinement, probably with insufficient or improper food.

The material of *S. californica* is insufficient for comparison, but shows the mean number of ova produced is 266.

Among the Cynthias the New York 1912 lot shows the highest mean, 374, but this is for only 6 insects and is worth little in a comparative way, but the fact that these prolific females were all that emerged from about 300 cocoons shows the survival of the most vigorous, and that the number of ova is in a way a criterion of vigor.

We feel sure that further gathering of data on these species from the same localities at intervals of a few years, or for successive years, would show some interesting results. Cannot one detect the direction in which the changes are leading the species by a study of such important problems as fecundity or longevity from year to year, as well as by elaborate studies on some morphological detail?

COMPLETENESS OF OVIPOSITION.

We have just discussed the number of eggs carried by these moths. We shall now take up in detail the question of complete or incomplete oviposition of these masses in relation to the mated or unmated condition of the individual.

All or a considerable portion of the eggs are deposited during the life of the insect, regardless of whether or not mating occurs. We have ascertained the number of eggs deposited by each female, and found what per cent this is of the total number carried by her. The population was divided into two great classes, the mated and the unmated, and then tabulated according to the per cent

Lot	Per Cent of Eggs Deposited by Each ♀											Total Individuals	Mean %	Max. No. of Eggs	Min. No. of Eggs
	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100				
Polyphemus, N. Y. 1912 .....U	....	....	....	....	....	....	....	1	....	5	5	11	87.7	327	89
Polyphemus, St. L. 1911.....U	....	....	....	....	....	1	....	1	....	....	5	7	83.6	321	116
Polyphemus, St. L. 1913.....U	....	....	....	....	2	1	1	1	....	9	29	43	87.3	335	23
Polyphemus, All .....U	....	....	....	....	2	2	1	2	....	9	34	50	86.8	....	....
Polyphemus, Fall River 1913.....U	1	....	....	1	....	....	....	....	....	6	34	42	89.6	382	0
Polyphemus, Ga. 1913.....U	1	....	1	....	2	1	....	1	1	5	22	34	81.9	403	0
Polyphemus, All combined .....U	2	....	1	1	4	3	1	4	1	25	95	137	86.5	....	....
Cynthia, N. Y. 1913.....M	....	....	....	....	3	2	2	1	3	4	12	27	76.9	423	63
Cynthia, N. Y. 1913.....U	1	7	4	....	1	1	1	1	....	1	....	17	22.4	230	0
Cynthia, N. Y. 1912.....U	....	....	....	....	....	1	1	3	1	....	....	6	61.6	320	167
Cynthia, Phila. 1913.....U	....	3	....	....	....	....	....	....	1	....	....	4	22.5	201	6
Cynthia, Phila. 1913.....M	....	1	1	3	1	3	1	2	2	2	4	20	57.5	329	30
Cynthia, All .....U	1	10	4	....	1	2	2	4	2	1	....	27	31.1	....	....
Cynthia, All .....M	....	1	1	3	4	5	3	3	5	6	16	47	68.6	....	....
Cecropia, N. Y. 1913.....U	....	....	....	....	1	....	....	....	....	1	2	4	77.5	302	140
Cecropia, N. Y. 1913.....M	....	....	....	....	1	3	....	....	1	1	11	17	80.9	403	83
Cecropia, St. L. 1913.....M	....	....	2	....	....	2	....	....	4	8	17	33	82.3	388	49
Cecropia, St. L. 1913.....U	....	....	....	1	....	3	....	3	....	3	5	15	72.3	441	72
Cecropia, St. L. 1913 (fluffy).....M	....	....	....	....	....	1	2	1	....	1	8	13	81.9	442	78
Cecropia, St. L. 1913 (fluffy).....U	....	....	....	2	....	....	2	....	1	1	1	7	59.3	360	67
Cecropia, All (fluffy).....	....	....	....	2	....	1	4	1	1	2	9	20	74.	....	....
Cecropia, All .....M	....	....	2	....	1	6	2	1	5	10	36	63	81.8	....	....
Cecropia, All .....U	....	....	....	3	1	3	2	3	1	5	8	26	69.6	....	....
Luna, St. L. 1911.....U	....	....	....	....	....	....	1	....	....	2	8	11	89.5	323	2
Luna, Pike Co. .....M	....	....	....	....	....	....	....	....	....	....	4	4	95.	226	121
Luna, Pike Co. .....U	....	....	....	....	1	....	....	....	....	1	6	8	86.2	321	62
Luna, All combined	....	....	....	....	1	....	1	....	....	3	18	23	89.3	....	....
Californica, Cal. 1912 .....M	....	....	....	....	....	....	....	....	....	....	2	2	95.	297	296
Californica, Cal., 1912 .....U	....	....	....	....	....	....	1	1	....	....	....	2	60.	161	138
Promethea, Mass. 1913.....U	....	....	1	1	4	3	....	1	7	7	12	36	73.3	394	19
Promethea, Creve Coeur 1911.....U	....	....	....	1	2	4	1	2	3	6	5	24	69.6	237	8
Promethea, Creve Coeur 1911.....M	....	....	....	2	1	....	1	2	2	6	8	22	76.8	277	26
Promethea, All combined .....U	....	....	1	2	6	7	1	3	10	13	17	60	71.8	....	....

of their eggs deposited. During 1911-12-13, the details of oviposition were recorded for 409 insects of the 24 lots as enumerated in table 20.[9]

Inspection of these figures shows that the mean percentage of oviposition in Polyphemus varies from 81.9 to 89.6%. There is only a slight difference in the mean per cents in the two lots from St. Louis, while a far more pronounced difference is at once apparent between the Fall River, Mass., and the Augusta, Ga., lots. Perceiving that the mean per cent for all polyphemus combined is 86.5, and that 95 females of the 137 deposited from 91 to 100% of their eggs, we must conclude that as a whole Polyphemus, even unfertilized, oviposit almost perfectly.

In the Cynthias we have two lots, one from New York and one from Philadelphia, but here we have notes based on the mated and unmated condition, and the effects of this factor are at once apparent. In the New York 1913 lot the mated ones give a mean per cent of oviposition of 76.9, while the unmated females give only 22.4%. To be sure the unmated females of the 1912 lot give a mean per cent of oviposition of 61.6, but these were the vigorous individuals already referred to which survived out of 300 cocoons. The Philadelphia material showed practically the same relation as the first; the mated insects deposited 57.5% of their eggs and the unmated ones only 22.5%.

The data for *S. cecropia* are self-explanatory, but we may call attention to the fact that here again the percents for the unmated insects were somewhat lower, while the Cecropias all taken together did not show such a well-perfected ability completely to oviposit as did the

---

[9] For instance, on the first line we read: *Telea polyphemus*. from New York, emerged 1912, and all remained unmated; 1 insect deposited from 61 to 70% of the total number of eggs she carried, 5 of them 81 to 90%, and 5 of them 91 to 100%; total, 11 insects. The mean per cent deposited by the whole population of 11 females was 87.7%, while the maximum actual number of eggs deposited by any individual of the lot was 327 and the minimum 89.

Polyphemus. When all of the lots of Cecropias are taken together, we find that copulation increases the percentage of oviposition by 12%.

Our Luna moths showed a high percentage of oviposition, 95% for the mated moths and 89.5 and 86.2% for the unmated St. Louis and Pike Co., respectively.

Our data on *S. californica*, although very insufficient, shows precisely the same tendencies as in the other species, the mated insects depositing 95% of their eggs, while the unmated moths reached only 60%. The Prometheas also give evidence of this tendency, but with a lower percentage of oviposition.

AGE WHEN FIRST EGGS WERE DEPOSITED.

We have elsewhere stated that mating is not the necessary precedent of oviposition, although it has become apparent in the preceding chapters that that function exerts some influence upon egg-laying. So it is not unusual that we at first thought perhaps the unfertilized females "held off egg-laying in the hope" of mating, and that if mating did not occur before late in life the ovipositing then commenced without it. With this question in mind we have compiled a table showing at what age 142 unfertilized females began to oviposit. (See Table 21.)

It will be noted that in no instance did oviposition begin after 7 days of age, nor on the first day[10] of the insect's life. 29% of the moths commenced ovipositing on the second day of their life, 40% on the third day, 19% on the fourth day and the remaining 12% of the insects began at the age of 5, 6 or 7 days to oviposit. This shows clearly that oviposition begins in due time, despite the fact that such oviposition is of no use for the propagation of the species, but that by conserving this ma-

---

[10] The first day of an insect's life is the same day wherein it emerged, but it may have emerged late in the day and hence its first day may consist of only a few hours.

TABLE 21.

Age When First Eggs Were Deposited.

Lot	Age—Days							Total
	1	2	3	4	5	6	7	
Promethea, St. L.....1911	..	2	8	9	5	4	..	28
Luna, St. L. 1911	..	1	7	1	2	..	..	11
Luna, Pike Co. 1911	..	..	4	4	1	..	..	9
Cynthia, N. Y. 1912	..	2	4	..	..	..	..	6
Polyphemus, St. L.....1911	..	1	5	1	..	..	..	7
Polyphemus, N. Y.....1912	..	7	4	..	..	..	..	11
Polyphemus, Ga. 1913	..	4	4	1	1	1	..	11
Polyphemus, St. L. 1913	..	18	11	8	1	..	1	39
Polyphemus, Fall River 1913	..	5	10	3	2	..	..	20
Total	..	40	57	27	12	5	1	142

terial until after mating much would be gained and nothing lost, since, as the foregoing discussions have shown, oviposition is more complete after mating than without it in spite of the expenditure of a comparatively long time for copulation.

In 1912 some Cecropia, kept in a living-room at the ordinary temperature, emerged in February and March. After emerging they were subjected to varying degrees of temperature. It was noticed that oviposition in these insects commenced much later than usual in life. We have previously recorded that unmated females of this species (these were unmated) usually oviposit on the second or third day after leaving the cocoon. Under these abnormal conditions these 19 insects first oviposited on the following days of age:

18 days.....	2 individuals.
17 days.....	1 individual.
15 days.....	3 individuals.
14 days.....	2 individuals.
13 days.....	2 individuals.
8 days.....	1 individual.
6 days.....	4 individuals.
5 days.....	2 individuals.
4 days.....	2 individuals.

No like tabulations are offered for the age of earliest oviposition of mated females, because even when the opportunity lay before the females to mate as early in life as they pleased, some ova were often deposited before copulation, and if not, oviposition was merely delayed until the conclusion of the mating period.

AGE AT WHICH THE GREATEST NUMBER OF EGGS WERE DEPOSITED.

In connection with the observations on the age at which the females begin to oviposit, it was thought desirable to find out at what age most of the eggs are deposited. This will give us an idea of the extent of the waste due to the oviposition which occurs too early for mating.

TABLE 22.

Age at Which the Greatest Number of Eggs Were Deposited.
(Unmated Insects.)

Lot	Age—Days.												Total
	2	3	4	5	6	7	8	9	10	11	12	14	
Promethea, St. L..1911	..	1	8	6	4	5	3	1	..	..	..	..	28
Luna, St. L. 1911	..	1	4	5	..	..	1	..	..	..	..	..	11
Luna, Pike Co.....1911	..	4	4	1	..	..	..	..	..	..	..	..	9
Cynthia, N. Y.....1912	..	1	2	..	2	1	..	..	..	..	..	..	6
Polyphemus, St. L. 1911	..	2	..	1	..	..	1	2	1	..	..	..	7
Polyphemus, N. Y. 1912	..	4	1	..	1	..	..	5	..	..	..	..	11
Polyphemus, Ga. ..1913	1	..	1	3	1	..	1	..	..	..	..	2	9
Polyphemus, Mass. 1913	..	..	4	2	6	1	2	..	1	1	..	..	17
Polyphemus, St. L. 1913	..	3	4	8	5	4	7	2	3	2	..	..	38
Total	1	16	28	26	19	11	15	10	5	3	..	2	136

Here we find that most of these 136 insects experienced their most productive day in the prime of their life, or at least before the decadence, for 66% had the most productive day between the second and sixth day of their

life. Hence, as we have said, the insect would lose little if the habit of oviposition were fixed at a later age in order to afford more assurance of a chance of fertilization, since egg-laying is heaviest just after copulation.

THE LAPSE OF TIME BETWEEN THE LAST OVIPOSITION AND DEATH IN RELATION TO THE NUMBER OF EGGS RETAINED AFTER DEATH.

When we consider longevity in its adjustment to egg-laying in order to insure the perpetuation of the species, one is confronted by these problems:

(a) Is life long enough to allow the female an opportunity to complete oviposition? or

(b) Are the females cut off by death before their eggs are all laid?

(c) Is oviposition complete and does the female live for any considerable length of time without eggs to lay, *i. e.*, a useless life?

This table embodies the data from 203 insects. The number of eggs retained by each female when overtaken by death, and the number of days it lived between its last egg-laying and death are presented in Table 23.

The data of table 23 are summarized in Table 24.

Here we readily see that there is no relation between the eggs retained and the time of death. We see in the "A class" 102 insects, half of all used in these observations, which died retaining eggs despite the fact of having 1, 2, 3 or even 6 days of life remaining in which to deposit them; 75 of the insects, or 37% of all observed (class B) were cut short in the midst of egg-laying. The remaining 26 insects, 13% of this population, oviposited completely, 11 of which dutifully died and the remainder lived a useless life of from 1 to 3 days after the completion of egg-laying.

When we see certain females, both fertilized and unfertilized, dying in the midst of oviposition, and others

TABLE 23.

No. of Eggs Retained, and Lapse of Time Between Last Egg-laying and Death.

Promethea U 1911		Promethea M 1911		Cecropia M 1913		Luna U St. L. 1911		Cynthia M Phil. 1913		Cynthia M N. Y. 1913		Polyphemus U St. L. 1913		Polyphemus U Ga. 1913		Polyphemus U F. Riv. 1913	
Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days	Eggs	Days
180	0	107	0	292	2	76	1	344	1	234	1	43	0	131	1	83	0
177	1	85	0	198	2	12	1	301	2	198	3	40	0	88	2	20	6
142	0	75	0	140	1	10	0	265	1	195	1	36	1	38	1	13	1
140	1	65	1	82	1	10	0	260	1	125	0	34	0	24	0	13	1
130	1	61	1	58	0	9	0	260	1	120	0	26	3	16	1	11	0
129	1	40	1	43	2	3	1	228	2	120	1	26	0	13	3	9	1
122	0	30	0	36	0	2	1	224	0	120	1	26	3	13	6	9	2
99	2	25	1	25	2	1	1	202	0	120	3	22	0	10	3	8	0
98	1	18	0	11	2	0	1	198	1	98	1	21	2	4	0	8	0
95	1	18	1	8	2	0	1	175	0	70	1	20	0	0	2	6	3
54	0	13	0	7	2	0	3	156	2	65	0	18	0	0	1	5	0
52	0	12	1	7	1			144	2	40	0	17	0			4	0
42	0	11	1	7	2	Pike Co. U, 1911		113	0	29	1	15	1	U, St. L. 1911		4	1
41	0	8	2	6	3			82	2	25	2	11	0			3	0
40	0	8	0	1	1	Eggs	Days	82	3	22	1	11	1	Eggs	Days	2	1
38	1	3	0	0				50	1	22	1	10	0			0	3
27	0	2	0			185	0	40	1	20	0	10	0	127	1		
27	2	1	0			26	2	28	0	20	1	10	0	108	0		
20	1	0	0			8	1	8	1	18	0	9	2	23	0		
20	0					0	2	0	0	16	1	8	1	9	1		
12	1					0	0			14	0	5	3	3	2		
6	2					0	1			13	0	5	0	0	1		
6	0					0	2			12	0	5	0				
5	0					0	0			12	2	4	1				
1	1									8	1	3	0				
1	0					Pike Co. M, 1911				0	0	3	0				
												3	0				
												3	0				
						Eggs	Days					2	0				
												2	3				
						2	1					2	1				
						0	2					2	0				
						0	1					0	2				
						0	1					0	1				
												0	0				
												0	0				
												0	0				
												0	0				

TABLE 24.

Lot	Mated or Unmated	Class									Total
		A1	A2	A3	A6	B	C0	C1	C2	C3	
St. L. Promethea 1911	U	10	4	0	0	12	1	0	0	0	27
St. L. Promethea 1911	M	7	1	0	0	10	1	0	0	0	19
St. L. Cecropia 1913	M	3	8	1	0	2	0	1	0	0	15
St. L. Luna 1911	U	2	3	0	0	3	0	2	0	1	11
Pike Co. Luna 1911	U	1	1	0	0	1	2	1	2	0	8
Pike Co. Luna 1911	M	0	0	0	0	1	0	2	1	0	4
Phila. Cynthia 1913	M	8	5	1	0	5	1	0	0	0	20
N. Y. Cynthia 1913	M	12	2	2	0	9	1	0	0	0	26
St. L. Polyphemus 1913	U	6	2	4	0	20	4	1	1	0	38
Ga. Polyphemus 1913	U	3	1	2	1	2	0	1	1	0	11
St. L. Polyphemus 1911	U	3	1	0	0	3	0	0	0	0	7
Mass. Polyphemus 1913	U	4	2	1	1	7	1	1	0	0	17
Total		59	30	11	2	75	11	9	5	1	203

Class A—The number of insects that retained eggs, and had sufficient time to oviposit them in one day (A1), two days (A2), three days (A3), six days (A6).

Class B—The number of insects cut short by death in the midst of egg-laying.

Class C—The number of insects that lived uselessly after completely ovipositing; no days (Co), one day (C1), two days (C2), three days (C3).

completely ovipositing and subsequently continuing a useless life, we can only conclude that egg-laying is not delicately adjusted to the economy of the species, but depends upon the physiological condition of the individual.

Proportion of Sexes.

Darwin, in his discussion of Sexual Selection in his "Descent of Man," places much importance on the proportion of sexes.

The published data on the proportion of sexes, especially of Lepidoptera, are of varying reliability since they often come from the casual collector's notes. As Darwin suggests, these collectors chase after the males because of their prettiness, and in some species the males

are more often on the wing while the heavily ova-laden females remain secluded. In the data here offered, this chance is eliminated since the material was gathered in the cocoon stage, and usually every cocoon seen in the field was taken.

From 1909 to 1911 we recorded the sex of 1214 Saturniid moths (Journ. Exp. Zool., Vol. xii, p. 196), 653 males and 561 females, or a proportion of 116 males to 100 females. In the years 1912 and 1913 we made further records on these moths, and from these data we have constructed the following table:

TABLE 25.

Proportion of Sexes.

Year	Species	Number		Proportion	
		Males	Females	Males	Females
1913	S. cynthia, N. Y.	75	75	100	100
1913	S. cynthia, Phila.	165	138	119	100
1913	C. promethea, Fall River	54	50	108	100
1912	S. californica, Cal.	7	7	100	100
1913	T. polyphemus, St. Louis.....	46	54	85	100
1913	T. polyphemus, Augusta, Ga....	316	285	146	100
1913	T. polyphemus, Fall River.....	101	82	123	100
1912	T. polyphemus, N. Y.....	24	15	160	100
1912	S. cecropia, St. L., R. des P.....	46	33	140	100
1913	S. cecropia, St. L. (fluffy).....	44	35	126	100
1913	S. cecropia, St. Louis.....	174	161	108	100
1913	S. cecropia, South St. Louis....	113	123	92	100
1913	S. cecropia, N. Y.....	76	67	113	100
1913	S. cecropia, Fall River, Mass....	5	4	125	100
	Total	**1226**	**1129**	**108**	**100**

These records of 2355 insects show the males again slightly in excess, 1226 males to 1129 females. By combining the data for the five years we find the total of 3569 insects comprises 1879 males and 1690 females, or 111 males to 100 females. We shall not presume to say how much significance may be attributed to the fact that

the proportion for all Saturniids observed in the first period, 1909-11, was 116 males to 100 females, while the records for 1912-13 show a proportion of 108 males to 100 females.

The Priority of Male Emergence.

In a study of the duration of life from the standpoint of efficiency for the perpetuation of the species, the fact that in practically all of our Saturniid material the males emerged from 1 to 5 days in advance of the females is a point worthy of thoughtful consideration. Here is the average priority[11] of the males of each population over the females:

TABLE 26.

Callosamia promethea, Fall River.....male priority, 3.07 days.
Philosamia cynthia, New York.....male priority, 2.64 days.
Philosamia cynthia, Philadelphia .....male priority, 1.09 days.
Samia cecropia, New York .....male priority, 3.47 days.
Samia cecropia, St. Louis (fluffy) .....male priority, 4.98 days.
Samia cecropia, St. Louis, River des Pêres....male priority, 2.56 days.
Samia cecropia, South St. Louis.....male priority, 1.84 days.
Telea polyphemus, Augusta, Ga. .....male priority, .23 days.
Telea polyphemus, St. Louis .....male priority, 1.48 days.
Telea polyphemus, Fall River.....female priority, 3.12 days.

These means give us a concise index to the actual condition occurring for the whole lot. For the details of the rate of emergence throughout the season, and the proportion of the sexes for each day, we present the data in the following curves. (See Pls. I-V.) For making these curves, the two groups of Cynthias, from Philadelphia and New York, were thrown into one lot, since, if plotted singly, the numbers were too small and too scattered upon the field to show the evidence clearly. For the same reason the Cecropias from the fluffy cocoons were combined with the rest of their lot, the River des

---

[11] The mean date of emergence of males and females was found, and this is the difference between the two.

Pêres Cecropias. The solid lines indicate the number of males emerging on the given day, and the dotted lines the females.

In one or two cases, especially the Polyphemus, the rate of emergence was so uniform or so scattered that this graphic method tells us less than does the simple mean. But in most cases the two lines run generally parallel, with only the space of a day or so between them. In fact, the nicety with which so nearly every increase or decrease in the frequencies of the males is followed by a corresponding change in the females is quite surprising. The female curve follows the male curve like its shadow. For instance in the South St. Louis Cecropias, fig. 6, one could almost estimate from a glance at the curves that the males appear on an average between 1 and 2 days before the females (the calculated mean is really 1.84 days).

Since the males have this precedence in 7 of the 8 lots of material here considered, we feel that it must be more than mere coincidence. The Polyphemus (figs. 2-4) show this difference less than do the other species; in one lot, the Massachusetts Polyphemus (fig. 3) the females show a decided priority, and in the other two lots the priority of the males is not so great as in the other species.

But throughout the series of curves we see unexplained vacillations in the emergence of the whole population, especially in the cases where the lines for both sexes suddenly drop low or to 0 in the midst of the season (as on May 22 in fig. 4, and May 10 in fig. 8), or where the whole population goes up or down together. Here another factor becomes apparent. We add to the list of figures a curve (the broken line, fig. 9) showing the mean temperature for each day, along with the emergence of all insects on that day, all species combined. This explains at a glance a great deal of the fluctuation of the emergence of the entire population, although we cannot see that it exerts a particularly greater influence upon one sex than upon the other. In a large number of cases

a high frequency corresponds to a high temperature on either the same or the preceding day, and a low frequency the corresponding reverse. It is only natural that the parallelism fails after June 10, when at the close of the season only a few stragglers are left to emerge.

Two explanations of this phenomenon of priority of male emergence present themselves. The one suggested by Darwin seems at first thought plausible; that among insects as well as among other groups of the animal kingdom the males emerge or arrive at maturity a little earlier than the females in order that they may have time to travel about and seek out mates, and that the first upon the field will win the mates and leave offspring to perpetuate their habits. In this way it is an adaptation for the good of the species. But on the other hand, in species like these where the duration of the entire life is but a few days, even these 2 or 3 days of priority of the male may suffice to deprive him entirely of a mate. Hence if this condition exist as a natural law it is at least subject to many drawbacks and defeats by other conflicting factors. The other explanation is that the duration of the pupal life of the male is shorter than that of the female, owing to the fact that the female has the large mass of ova to produce, and that this difference in time required for development becomes apparent at this particular point in the life of the individual.

Fertility of Saturniid Eggs in Relation to the Mating Period.

INTRODUCTORY REMARKS.

The Saturniid moths, at least the ones with which we have worked, spend much time in mating. The Cecropia moth spends from 10 to 48 hours in copulo, or 21 hours on an average.[12] We have found that a normal mating for all of these species Cynthia, Polyphemus, Cecropia or Californica, consists of a continuous period in copulo

[12] Trans. Acad. Sci., St. Louis, 20: 309, 1911.

from early morning, 4 to 6 o'clock, to the evening of the same day, the couples usually severing some time between 5 and 9 o'clock. This length of time seems enormous when we consider the brief period they have wherein to live and reproduce. We wondered whether this prolonged period was of any increased value to the species; whether a longer period of copulation tended to insure the fertility of all of the eggs, or whether a large number of ova required a longer period of mating to insure the fertility of all.

We also wanted to know just what per cent of the eggs were fertile, and if there was a higher percentage of fertility among the first eggs deposited than among the last.

This led to the experiments with Cecropia eggs from insects which mated from 3 to 48 hours.[13] In this study we found that there is absolutely no relation between the time spent in copulation and the fertility of the eggs; that those insects which remained in copulo for 3 to 15 hours deposited eggs showing just as high a per cent of fertility as those which continued for 18 to 48 hours. We also found that those insects which carried an abnormally large number of eggs had just as large a per cent of fertility as did those with smaller numbers. In the former work we found 77% of all the eggs were fertile and 23% infertile.

In 1913 similar work was carried on with 132 females of the following 8 lots of Saturniids:

22 ♀'s Samia cecropia, River des Pêres, St. Louis, normal.....1913
14 ♀'s Samia cecropia, River des Pêres, St. L., fluffy cocoons.....1913
11 ♀'s Samia cecropia, South St. Louis.....1913
16 ♀'s Samia cecropia, New York 1913
27 ♀'s Philosamia cynthia, Philadalphia 1913
30 ♀'s Philosamia cynthia, New York 1913
10 ♀'s Telea polyphemus, Fall River (2♀'s) 1913
Telea polyphemus, St. Louis (1♀) 1912
Telea polyphemus, New York (1♀) 1912
Telea polyphemus, Augusta, Ga. (6♀'s) 1913
2 ♀'s Samia californica, California 1912

[13] The details of this work were published in Biol. Bull., 24: 245-250, 1913.

The individuals were isolated immediately upon leaving the cocoon, and placed one pair in a cage. Frequently some eggs were dropped ere mating began, but these were in all cases vigilantly removed and not taken into account. Early each morning the eggs from each cage were counted and placed in a vial with a cotton stopper and labeled; this comprised the oviposition of the preceding 24 hours. The emerging caterpillars all died in their vials. Later, these as well as the empty egg-shells were counted, and all of the eggs from which nothing had hatched were dissected, to find whether they contained an embryo or were infertile. In all of this material, as in the former lot, all of the eggs that were shriveled proved infertile and contained only a dried mass of yellowish substance.[14] It also sometimes happened that the smooth, round eggs of the Cecropia contained a fully-formed insect which had been unable to bite its way out. There were, however, a few exceptions in each class, and the external appearance was not relied upon, but each egg was cut open and the contents examined. The small number of fertile eggs which had the opening partly cut by the caterpillar in attempting to emerge were in every case counted with those which normally emerged.

The tables give the number of hours spent by each female in copulo. The letter "N" signifies a normal, free mating, which means that mating began in the early morning hours and continued throughout the day until evening. Each day's deposit is recorded separately, and separated into the following four classes:

T—Total number of eggs deposited that day.

F H—The number in this day's deposit that were fertile and hatched.

F U—The number fertile but unhatched.

Inf—Infertile.

*—Eggs were deposited on this day, but were included in the next day's count.

---

[14] In the Cynthia eggs this mass was dark brown.

SAMIA CECROPIA.

Table 27 presents the data of the fertility of the River des Pêres Cecropias coming from the normal cocoons.

We have 9 insects recorded above which mated from 4 to 6 hours. A glance at the total column promptly tells us that the per cent of infertility is so low that the egg masses may be called practically all fertile. These pairs were artificially separated after having been together for 5 or 6 hours, or in one case 4 hours.

In connection with the normal period of copulation, 15 to 18 hours, we have 11 insects which show the per cent of infertility to be correspondingly low. On the whole, this entire lot of eggs were very fertile; the 4704 eggs included only 106 infertile ones, or 2.2%, while 97.8% of the aggregate were fertile.

We cannot see any perceptible difference in the fertility of the early or late deposition, but the smallness of the per cent of the infertile eggs in the total deposit would make it an increasingly delicate task to detect such a difference. This year's material shows a much higher degree of fertility than that for the year 1911.

In the total F. U. column of the table is given the number of eggs in which the embryo partially developed but for some unknown cause died in the shell. These constitute 3.8% of the whole number of eggs deposited, and 4% of the fertile eggs, a far smaller proportion than the 1911 eggs, which showed 11% and 14.5% respectively unhatched though fertile.

Here we see clearly that a shortened period of mating does not reduce the fertility of the eggs; that the insect could economize on time spent in copulation and still cause no reduction in the progeny, or that in some cases she might even increase the number of her offspring by utilizing this extra time for oviposition, in which she might otherwise be cut short.

TABLE 27.

Fertility of Eggs of S. cecropia. *St. Louis, River des Peres, 1913.*

(Normal Cocoons.)

♀ No.	Hours in Copulo	1st Day's Deposit				2nd Day's Deposit				3rd Day's Deposit				4th Day's Deposit				5th Day's Deposit				6th Day's Deposit				7th Day's Deposit				Total			
		T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	Dep.	F H	F U	Inf.
1	4	51	49	2	0	*	...	...	...	122	119	0	3	126	110	16	0	10	10	0	0	...	...	...	...	...	...	...	...	309	288	18	3
2	5–6	107	88	15	4	139	130	7	2	12	10	2	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	258	228	24	6
3	5–6	110	110	0	0	*	...	...	...	123	116	5	2	64	61	3	0	...	...	...	...	...	...	...	...	...	...	...	...	297	287	8	2
4	5–6	151	143	7	1	*	...	...	...	64	64	0	0	107	100	4	3	1	1	0	0	...	...	...	...	...	...	...	...	323	308	11	4
5	5–6	65	61	2	2	*	...	...	...	209	200	7	2	*	...	...	...	63	58	4	1	...	...	...	...	...	...	...	...	337	319	13	5
6	5–6	171	164	0	7	*	...	...	...	42	34	8	0	*	...	...	...	14	13	1	0	...	...	...	...	...	...	...	...	227	211	9	7
7	5–6	167	167	0	0	*	...	...	...	72	67	0	5	23	9	2	12	...	...	...	...	...	...	...	...	...	...	...	...	262	243	2	17
8	5–6	152	147	4	1	*	...	...	...	53	52	1	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	205	199	4	2
9	5–6	24	18	6	0	36	31	5	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	60	49	11	0
10	N	200	193	1	6	59	59	0	0	27	22	5	0	51	49	2	0	10	6	3	1	1	1	0	0	...	...	...	...	348	330	11	7
11	N	45	40	0	5	2	2	0	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	47	42	0	5
12	N	7	5	0	2	54	53	0	1	*	...	...	...	95	95	0	0	42	31	3	8	...	...	...	...	...	...	...	...	198	184	3	11
13	N	31	26	2	3	47	46	1	0	97	89	4	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	175	161	7	7
14	N	62	62	0	0	147	145	2	0	79	63	14	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	288	270	16	2
15	N	81	77	2	2	*	...	...	...	32	32	0	0	*	...	...	...	*	...	...	...	197	182	13	2	...	...	...	...	310	291	15	4
16	N	72	72	0	0	*	...	...	...	192	186	5	1	47	44	1	2	...	...	...	...	...	...	...	...	...	...	...	...	311	302	6	3
17	N	10	9	1	0	*	...	...	...	33	33	0	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	43	42	1	0
18	N	*	...	...	...	198	198	0	0	182	179	2	1	8	7	1	0	...	...	...	...	...	...	...	...	...	...	...	...	388	384	3	1
19	N	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	210	175	16	19	210	175	16	19
20	N	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	108	106	1	1	108	106	1	1
Total....		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4704	4419	179	106

The same kind of notes were made on 13 of the insects from the large, fluffy cocoons in an attempt to detect any points which might seem characteristic of this group. (See Table 28.)

Here we have 9 insects which mated normally, and all but one yield a very small number of infertile eggs. We have also 2 females with the mating period prolonged to 36 and 38 hours; here also is a very low per cent of infertility. Then we have the opposite extreme, 2 which were separated after only 6 and 2 hours in mating, and even here the fertility is almost perfect. In the earlier series of experiments we were afraid to cut the mating shorter than 3 hours, but here a 2-hour period in copulo seemed quite as sufficient for perfect results as a much longer one.[15] On the whole, the insects from the fluffy cocoons show a very slightly higher per cent of infertility than the normal Cecropias of this lot, but the influence of two extreme individuals is responsible for this. This infertility, however, even if it were more than mere chance of this material, could not be of any effect toward the elimination of this variety (if these do constitute a variety, with their own peculiar characteristics maintained by heredity), because, as we have seen in a previous chapter, they produce a larger number of ova than do the normal Cecropias. Hence fluffiness is not correlated with fertility, though it might be with fecundity. In this lot we find a low proportion, 5%, of the fertile ova which failed to produce larvae. This indicates that this group of parents are a vigorous stock. We also see in this lot no correlation between early and late oviposition and infertility.

For some undiscovered reason, the material of this year shows a much lower per cent of infertility than did the 1911 collections. Also in this lot we found no individuals which, after either a normal, prolonged or shortened mating, still had all of the eggs infertile as we did

---

[15] See p. 61 for discussion of 1-hour matings.

TABLE 28.

Fertility of Eggs of S. cecropia. *St. Louis, River des Peres, 1913.*

(Fluffy Cocoons.)

♀ No.	Hours in Copulo	1st Day's Deposit				2nd Day's Deposit				3rd Day's Deposit				4th Day's Deposit				5th Day's Deposit				6th Day's Deposit				7th Day's Deposit				Total			
		T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	Dep.	F H	F U	Inf.
21	N	93	89	1	3	121	119	0	2	*	...	...	...	5	5	0	0	*	...	...	...	27	24	2	1	...	...	...	...	246	237	3	6
22	N	5	5	0	0	79	79	0	0	72	72	0	0	82	78	4	0	51	51	0	0	12	12	0	0	...	...	...	...	301	297	4	0
23	N	24	22	2	0	96	86	10	0	101	66	6	29	50	48	1	1	10	10	0	0	23	21	1	1	1	1	0	0	305	254	20	31
24	38	67	65	1	1	58	52	5	1	99	96	2	1	111	106	3	2	77	76	0	1	30	27	1	2	...	...	...	...	442	422	12	8
25	36	44	44	0	0	49	48	0	1	90	79	10	1	69	63	6	0	25	24	1	0	...	...	...	...	...	...	...	...	277	258	17	2
26	N	6	5	1	0	23	21	2	0	131	131	0	0	0	0	0	0	149	148	0	1	2	2	0	0	...	...	...	...	311	307	3	1
27	N	122	88	0	34	176	160	3	13	0	0	0	0	43	36	6	1	19	8	10	1	...	...	...	...	...	...	...	...	360	292	19	49
28	N	171	128	39	4	6	5	1	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	177	133	40	4
29	N	166	159	3	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	166	159	3	4
30	N	240	228	6	6	*	...	...	...	100	97	0	3	58	42	14	2	...	...	...	...	...	...	...	...	...	...	...	...	398	367	20	11
31	N	102	98	0	4	68	54	12	2	*	...	...	...	53	43	9	1	...	...	...	...	...	...	...	...	...	...	...	...	223	195	21	7
32	6	164	148	9	7	*	...	...	...	103	102	0	1	11	8	3	0	...	...	...	...	...	...	...	...	...	...	...	...	278	258	12	8
33	2	78	65	2	11	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	78	65	2	11
Total....		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3562	3244	176	142

in the first lot. Then again we find that the duration of copulation does not influence the fertility of the eggs, whether they be few or many. (See Table 29.)

We shall not go into the analysis of these data of the South St. Louis Cecropias, since the per cents correspond so closely to those already discussed. (See Table 30.)

The New York Cecropias furnish very interesting comparative data. The per cents of fertility and viability are practically identical with those from a distant locality of different climate. (See Table 30.)

This lot is rich in 2-hour matings, which give the same good results of high fertility—much higher in fact than some of the normal matings. This again conclusively demonstrates that 2 hours of copulation is quite sufficient for the propagation of the race.

PHILOSAMIA CYNTHIA.

Our observations on the fertility in *P. cynthia* are based upon two lots of material, one from New York City and one from Philadelphia, Pa.

This species seems not to be monogamous, like our Cecropias, but some of the New York insects mated twice, and some members of the Philadelphia lot mated two and three times. Normal mating in this species is the same as in the Cecropias, *i. e.*, continuous mating from early morning until about dark, or sometimes a little later. It will be noted that in both tables a few individuals have no record of length of time in mating. In these cases they were found already in copulo when the examination was made in the morning, and they had already separated before the usual time of inspection in the afternoon, so we do not know with certainty the exact duration of the mating. In the cases where they were artificially separated, the duration is indicated by the number placed after the date of mating.

The counting of the empty egg-shells and the dead larvae in each vial was a comparatively easy task, but

TABLE 29.

Fertility of Eggs of S. cecropia. *South St. Louis, 1913.*

♀ No.	Hours in Copulo	1st Day's Deposit				2nd Day's Deposit				3rd Day's Deposit				4th Day's Deposit				5th Day's Deposit				6th Day's Deposit				7th Day's Deposit				Total			
		T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	Dep.	F H	F U	Inf.
34	N	8	7	0	1	22	22	0	0	42	40	2	0	96	96	0	0	67	65	2	0	29	25	4	0	3	3	0	0	267	258	8	1
35	28	65	44	21	0	113	82	26	5	39	27	11	1	2	1	1	0	...	...	...	...	...	...	...	...	...	...	...	...	219	154	59	6
36	N	50	48	2	0	131	120	4	7	*	...	...	...	119	116	1	2	5	3	1	1	...	...	...	...	...	...	...	...	305	287	8	10
37	N	223	221	0	2	28	28	0	0	*	...	...	...	31	27	4	0	*	...	...	...	*	...	...	...	30	25	3	2	312	301	7	4
38	N	24	21	2	1	187	180	5	2	*	...	...	...	*	...	...	...	*	...	...	...	67	57	10	0	...	...	...	...	278	258	17	3
39	N	73	60	3	10	96	94	2	0	*	...	...	...	60	59	1	0	*	...	...	...	*	...	...	...	14	14	0	0	243	227	6	10
40	N	12	10	2	0	*	...	...	...	75	75	0	0	*	...	...	...	110	104	5	1	*	...	...	...	74	63	5	6	271	252	12	7
41	5½	7	7	0	0	*	...	...	...	152	149	3	0	*	...	...	...	77	74	3	0	*	...	...	...	6	6	0	0	242	236	6	0
42	6	70	65	5	0	*	...	...	...	92	80	9	3	*	...	...	...	45	43	2	0	...	...	...	...	...	...	...	...	207	188	16	3
43	N	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	123	111	4	8	123	111	4	8
44	2	146	116	14	16	50	47	3	0	*	...	...	...	15	13	0	2	...	...	...	...	...	...	...	...	...	...	...	...	211	176	17	18
Total....		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2678	2448	160	70

TABLE 30.

Fertility of Eggs of S. cecropia. *New York, 1913.*

♀ No.	Hours in Copula	1st Day's Deposit				2nd Day's Deposit				3rd Day's Deposit				4th Day's Deposit				5th Day's Deposit				6th Day's Deposit				Total			
		T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	Dep.	F H	F U	Inf.
45	2	178	118	60	0	*	...	...	...	70	32	38	0	...	...	...	...	...	...	...	...	...	...	...	...	248	150	98	0
46	N	98	94	1	3	53	51	1	1	*	...	...	...	3	3	0	0	1	1	0	0	...	...	...	...	155	149	2	4
47	N	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	170	166	4	0	170	166	4	0
48	2	62	61	1	0	*	...	...	...	21	17	3	1	...	...	...	...	...	...	...	...	...	...	...	...	83	78	4	1
49	2	*	...	...	...	177	175	1	1	102	98	4	0	*	...	...	...	*	...	...	...	44	36	6	2	323	309	11	3
50	N	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	264	254	10	0	264	254	10	0
51	N	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	326	266	52	8	326	266	52	8
52	N	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	295	235	20	40	295	235	20	40
53	N	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	248	220	7	21	248	220	7	21
54	5½	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	279	264	5	10	279	264	5	10
55	5	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	280	233	21	26	280	233	21	26
56	5	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	336	311	8	17	336	311	8	17
57	N	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	259	244	14	1	259	244	14	1
58	N	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	190	175	6	9	190	175	6	9
59	N	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	*	...	...	...	226	207	5	14	226	207	5	14
Total....		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3682	3261	267	154

dissecting the eggs which did not hatch was a far more difficult task than in the Cecropia studies. In the latter species, the eggs which gave forth nothing showed upon dissection one of two alternatives; the egg contained either a well-formed embryo, easily distinguished, or a yellow mass of dried egg substance. In the Cynthias the eggs were very much smaller, and the contents, whether the egg mass or the dead embryo, were in most cases dark brown, and it required examination under magnification to determine whether the masses were infertile or had partly developed. This scrutiny revealed the fact that mortality had occurred at all stages of the embryonic development. (See Table 31.)

Here are 30 females which deposited a total of 6931 eggs. Of this number 2815 (or 41%) normally hatched, and 1584 (23%) were infertile, while the remaining 36% of the total number deposited failed to develop to maturity, or died in embryo. This is the most extreme case of waste that we have yet found. Attempts were made to sift the data and cull some indication of the causes of this, but nothing positive was found.

The females in this table, 15 in number, which experienced one mating of unknown duration (probably slightly abbreviated), were brought together in a separate table, but these showed all degrees of fertility and infertility. The 5 moths which mated twice deposited a large number of infertile ova, in spite of the additional opportunity for their fertilization. The 7 females which went through a normal period of mating were likewise assembled. The fertility in these is fairly good although the per cent. does not run nearly so high as in the other species earlier considered. There are only 3 individuals in this table in which the artificial interruption of mating was practiced. One was in copulo 6 hours, but the next day mated again; in this case almost all of the eggs were fertile. In the next, after a 3-hour period of mating 68 eggs, or about 20% of the whole number, were infertile, and the

TABLE 31.

Fertility of Eggs of P. cynthia. New York, 1913.

♀ No.	Hours in Copulo	1st Day's Deposit				2nd Day's Deposit				3rd Day's Deposit				4th Day's Deposit				5th Day's Deposit				6th Day's Deposit				Total			
		T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	Dep.	F H	F U	Inf.
60	N	136	130	5	1	25	13	2	10	13	5	5	3	15	2	3	10	...	...	...	...	...	...	...	...	189	150	15	24
61	?	82	45	31	6	29	11	14	4	6	2	4	0	...	...	...	...	...	...	...	...	...	...	...	...	117	58	49	10
62	?	77	21	47	9	66	7	52	7	53	0	23	30	4	0	4	0	...	...	...	...	...	...	...	...	200	28	126	46
63	N	180	130	50	0	43	0	40	3	34	0	32	2	2	0	1	1	...	...	...	...	...	...	...	...	259	130	123	6
64	N	48	14	32	2	12	0	12	0	3	0	1	2	...	...	...	...	...	...	...	...	...	...	...	...	63	14	45	4
65	?	22	2	12	8	75	15	33	27	36	1	23	12	116	20	96	0	...	...	...	...	...	...	...	...	249	38	164	47
66	?	59	8	38	13	22	6	16	0	...	...	...	...	1	0	1	0	...	...	...	...	...	...	...	...	82	14	55	13
67	N	7	0	6	1	172	69	92	11	29	3	14	12	16	0	0	16	7	0	0	7	...	...	...	...	231	72	112	47
68	?	208	190	13	5	15	0	15	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	223	190	28	5
69	N+N	121	83	28	10	138	0	135	3	53	0	40	13	57	0	47	10	27	0	5	22	27	0	0	27	423	83	255	85
70	?	71	0	64	7	54	0	54	0	53	0	33	20	35	7	16	12	56	10	28	18	...	...	...	...	269	17	195	57
71	N	44	6	26	12	53	22	29	2	11	1	9	1	11	2	9	0	...	...	...	...	...	...	...	...	119	31	73	15
72	N	143	30	103	10	47	2	28	17	105	50	40	15	84	16	16	52	...	...	...	...	...	...	...	...	379	98	187	94
73	?	168	84	79	5	85	29	50	6	6	0	0	6	...	...	...	...	...	...	...	...	...	...	...	...	259	113	129	17
74	N+N	172	120	29	23	26	0	16	10	44	5	38	1	...	...	...	...	...	...	...	...	...	...	...	...	242	125	83	34
75	?+?	126	32	79	15	124	20	102	2	77	15	30	32	40	0	21	19	27	0	9	18	...	...	...	...	394	67	241	86
76	?	200	130	60	10	64	20	25	19	24	0	7	17	...	...	...	...	...	...	...	...	...	...	...	...	288	150	92	46
77	?	149	43	43	63	106	50	34	22	73	59	8	6	2	0	1	1	...	...	...	...	...	...	...	...	330	152	86	92
78	?	66	28	31	7	179	157	12	10	49	20	25	4	2	0	2	0	...	...	...	...	...	...	...	...	296	205	70	21
79	?	117	0	0	117	24	0	0	24	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	141	0	0	141
80	?	273	248	10	15	37	9	23	5	27	5	14	8	...	...	...	...	...	...	...	...	...	...	...	...	337	262	47	28
81	?	165	105	55	5	76	43	28	5	23	13	10	0	...	...	...	...	...	...	...	...	...	...	...	...	264	161	93	10
82	?	76	28	13	35	120	50	25	45	126	0	8	118	2	0	0	2	...	...	...	...	...	...	...	...	324	78	46	200
83	6+?	172	145	12	15	26	11	12	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	198	156	24	18
84	3	195	150	30	15	50	22	13	15	68	0	30	38	3	0	3	0	...	...	...	...	...	...	...	...	316	172	76	68
85	3	83	48	30	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	83	48	30	5
86	N	116	66	20	30	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	116	66	20	30
87	N+N	28	0	0	28	67	0	0	67	14	0	0	14	...	...	...	...	...	...	...	...	...	...	...	...	109	0	0	109
88	?	140	123	2	15	39	3	10	26	3	1	1	1	...	...	...	...	...	...	...	...	...	...	...	...	182	127	13	42
89	?+?	63	0	10	53	66	0	40	26	66	0	5	61	54	0	0	54	...	...	...	...	...	...	...	...	249	0	55	194
Total.....		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6931	2815	2532	1584

third case, after a like period of 3 hours, showed a very low per cent. of infertility.

With so much individuality apparent we cannot yet point out any causal factors of this variability in the fertility of this species. We present the data of the "Fertile Unhatched" column without any more comment than to say that here too we find the same variability as elsewhere; in the ova of some individuals the embryonic mortality is high, and in others comparatively low. Whether or not this lack of viability of the fertile ova is due to some factor in the St. Louis conditions, temperature or humidity, we cannot tell. To be sure this species is typical of the Atlantic states and does not occur at St. Louis, and the environmental conditions here may have affected this material. But the fact that a considerable per cent. of the fertile eggs hatched normally shows that the climate is not intolerable to some of them at least, so the problem remains: What are the special characteristics or weaknesses of certain other individuals which predetermine that they shall not be able successfully to reproduce, or having been produced, to survive?

Parallel work was done with 27 fertilized females from Philadelphia, with the results shown in the table below. (See Table 32.)

In this lot we see an appallingly great degree of infertility, and also a much higher per cent. of the fertile eggs which failed to hatch. Of the 4416 eggs deposited by this lot only 1215, or 27.5%, gave forth caterpillars. Even the New York lot, which we considered very weak, gave 41% fertility. Almost one-half of these eggs laid were infertile, and about half of the fertile eggs failed to bring their development to completion. Thus we see this Philadelphia population in a sad plight in regard to their perpetuation. Elimination in the early stages of life is common in all branches of the animal kingdom, but this, an elimination of nearly three-fourths of the

TABLE 32.

Fertility of Eggs of S. cynthia. *Philadelphia, 1913.*

No. of ♀	Hours in Copulo	1st Day's Deposit				2nd Day's Deposit				3rd Day's Deposit				4th Day's Deposit				5th Day's Deposit				6th Day's Deposit				Total			
		T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	Dep.	F H	F U	Inf.
90	N	255	232	15	8	20	0	15	5	23	0	11	12	12	0	0	12	11	0	0	11	...	...	...	...	321	232	41	48
91	5	124	84	18	22	21	1	5	15	9	0	1	8	...	...	...	...	...	...	...	...	...	...	...	...	154	85	24	45
92	?	258	198	45	15	13	0	7	6	3	0	0	3	...	...	...	...	...	...	...	...	...	...	...	...	274	198	52	24
93	N	73	8	42	23	21	3	15	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	94	11	57	26
94	?+N	68	39	15	14	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	68	39	15	14
95	N	175	110	65	0	22	1	5	16	4	0	1	3	...	...	...	...	...	...	...	...	...	...	...	...	201	111	71	19
96	?	235	201	15	19	27	0	11	16	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	262	201	26	35
97	N	117	69	30	18	44	0	34	10	11	0	9	2	3	0	0	3	1	0	0	1	1	0	0	1	177	69	73	35
98	?+?+?	208	154	15	39	...	...	...	...	4	0	3	1	12	0	4	8	...	...	...	...	...	...	...	...	224	154	22	48
99	?	65	2	33	30	16	0	14	2	71	0	49	22	1	0	0	1	...	...	...	...	...	...	...	...	153	2	96	55
100	?+?	115	60	40	15	7	0	3	4	4	0	3	1	...	...	...	...	...	...	...	...	...	...	...	...	126	60	46	20
101	?	49	0	45	4	13	0	2	11	3	0	0	3	5	0	0	5	6	0	0	6	2	0	0	2	78	0	47	31
102	7+2+?	159	45	109	5	88	5	60	23	29	0	23	6	26	0	1	25	3	0	0	3	...	...	...	...	305	50	193	62
103	?	135	0	0	135	6	0	0	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	141	0	0	141
104	?	21	0	0	21	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	21	0	0	21
105	?	33	0	0	33	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	33	0	0	33
106	1	51	0	25	26	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	51	0	25	26
107	?+?+?	28	0	10	18	43	0	18	25	59	0	19	40	37	0	0	37	3	0	0	3	...	...	...	...	170	0	47	123
108	?+?	117	0	40	77	48	1	20	27	28	0	0	28	40	0	10	30	6	0	0	6	...	...	...	...	239	1	70	168
109	?	60	0	15	45	52	0	25	27	61	0	60	1	11	0	3	8	...	...	...	...	...	...	...	...	184	0	103	81
110	?	...	...	...	...	147	0	102	45	55	0	0	55	14	0	0	14	...	...	...	...	...	...	...	...	216	0	102	114
111	?	61	0	26	35	50	2	10	38	7	0	0	7	...	...	...	...	...	...	...	...	...	...	...	...	118	2	36	80
112	?+?	8	0	0	8	22	0	0	22	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30	0	0	30
113	?	135	0	0	135	49	0	0	49	34	0	0	34	47	0	0	47	...	...	...	...	...	...	...	...	265	0	0	265
114	?+?	27	0	0	27	112	0	0	112	39	0	0	39	...	...	...	...	...	...	...	...	...	...	...	...	178	0	0	178
115	N+?	12	0	0	12	32	0	0	32	77	0	0	77	...	...	...	...	...	...	...	...	...	...	...	...	121	0	0	121
116	?	203	0	0	203	9	0	0	9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	212	0	0	212
Total.....		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4416	1215	1146	2055

ova produced before they had even hatched from the egg, is unusual. Not only the means for the entire lot show a low per cent. of fertility, but the records of the individuals also show that only 8 out of the 27 females were successful in contributing even a fair number of living young to the next generation. Nor can we glean from these data any evidence that repeated or prolonged matings increase the fertility of the egg masses, or that somewhat abbreviated mating reduces it. The careful search for such evidence revealed the fact that those individuals which mated the full time or even twice or thrice showed as high a proportion of infertile or non-viable ova as the others, while good and bad cases of fertility appear also in those females which mated only a few hours. This evidence strengthens our belief that in this species, as in Cecropia, an amount of sperm sufficient for the fertilization of the ordinary mass of ova enters the seminal receptacle very early in the mating period; the ova pass through this male element, and if they are capable of fertilization they become fertilized by this contact, and those unfit pass out without the wherewithal for development, and copulation for a greater length of time will have no effect upon these ova which are not perfect to receive the spermatozoa.

TELEA POLYPHEMUS.

The difficulty of inducing the Polyphemus to mate has been explained elsewhere. The data on 10 fertilized females from several localities are given below. (See Table 33.)

The 2 insects from Fall River deposited ova of a high per cent. of fertility, but the one which mated only 9 hours was superior in fertility to her sister who spent 13 hours in copulo. The one female which was taken at the light one evening in St. Louis, with history unknown, deposited 66 eggs, every one of which was fertile. The 6 females from Augusta, Ga., which mated from 12

TABLE 33.

Fertility of Eggs of T. polyphemus.

♀ No.	Hours in Copulo	1st Day's Deposit				2nd Day's Deposit				3rd Day's Deposit				4th Day's Deposit				5th Day's Deposit				6th Day's Deposit				7th Day's Deposit				Total			
		T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	Dep.	F H	F U	Inf.
†117	9	116	112	4	0	146	144	0	2	25	25	0	0	22	21	1	0	24	23	0	1	16	9	6	1	5	5	0	0	354	339	11	4
†118	13	74	57	5	12	126	125	0	1	42	39	2	1	10	9	0	1	4	4	0	0	4	4	0	0	...	...	...	...	260	238	7	15
‡119	?	46	46	0	0	11	11	0	0	4	4	0	0	5	5	0	0	...	...	...	...	...	...	...	...	...	...	...	...	66	66	0	0
§120	?	70	50	15	5	31	24	7	0	14	14	0	0	5	5	0	0	...	...	...	...	...	...	...	...	...	...	...	...	120	93	22	5
*121	12	172	157	5	10	29	11	16	2	1	1	0	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	202	169	21	12
*122	?	112	78	21	13	3	3	0	0	5	3	0	2	4	0	0	4	...	...	...	...	...	...	...	...	...	...	...	...	124	84	21	19
*123	15	45	25	17	3	12	8	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	57	33	19	5
*124	15	10	7	2	1	11	8	0	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	21	15	2	4
*125	14	209	116	52	41	13	2	2	9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	222	118	54	50
*126	?	140	125	11	4	28	23	4	1	15	9	6	0	8	4	0	4	...	...	...	...	...	...	...	...	...	...	...	...	191	161	21	9
Total....		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1617	1316	178	123

†Fall River, Mass. ‡St. Louis, 1912. §New York, 1912. *Augusta, Ga.

TABLE 34.

Fertility of S. Californica. California, 1912.

♀ No.	Hours in Copulo	1st Day's Deposit				2nd Day's Deposit				3rd Day's Deposit				4th Day's Deposit				5th Day's Deposit				6th Day's Deposit				7th Day's Deposit				Total			
		T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	T	F H	F U	Inf.	Dep.	F H	F U	Inf.
127	28	232	96	88	48	18	18	0	0	36	18	13	5	4	4	0	0	4	1	0	3	2	0	0	2	...	...	...	...	296	137	101	58
128	13	195	166	28	1	71	70	0	1	31	14	17	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	197	150	45	2
Total....		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	493	287	146	60

to 15 hours, gave a total of 817 eggs, 12% of which were infertile.

SAMIA CALIFORNICA.

For the *Samia californica* we have notes on only 2 insects. (See Table 34.)

The first mated 28 hours and yielded 20% of infertile eggs, while the second, after only a 13-hour mating had barely 1% of infertile eggs.

THE MINIMUM DURATION OF MATING IN RELATION TO FERTILITY.

In our four Cecropia tables already presented are 6 females which mated only 2 hours, yet had a perfectly normal proportion of fertile eggs, while the seventh was entirely infertile. We were eager to find just what the minimum duration of copulation could be to insure the fertility of a normal amount of eggs.

The period of mating of 3 females was limited to 1 hour, and of 1 female, to 2 hours; from all these, not one egg was fertile.

Hence the minimum duration of mating required for complete fertilization of the egg mass must be between 1 and 2 hours. Of course the one insect which mated for 2 hours and yet gave no evidence of fertilization may have been sterile, since we have data on a number of 2-hour matings, recorded elsewhere, a large proportion of which proved quite fertile.

Period of Incubation.

SAMIA CECROPIA.

In a previous series of observations on the period of incubation of Crecopia eggs,[16] we found the period of incubation for the eggs deposited each day by each female to vary from 6 to 11 days. The length of time for the great majority was 8 or 9 days. All but two of the 36

[16] **Psyche. 19: 69, 1912.**

females deposited their first eggs between June 9 and 26. Our principal object in this work was to see whether or not the eggs which were laid on different days required the same length of time for their development, whether the first eggs deposited have the same period of incubation as do the last eggs. In the notes already referred to we found this time to be the same for all the ova of each female, whether they were laid on the first or on the last day of her oviposition, and in the few cases where fluctuation occurred in the eggs of an individual, the variation was within one day. We therein suggested that when such variation occurred it may have been due to climatic variations.

The same problem was pursued in 1912-13 on the four species of Saturniids herein dealt with. The results of the work are summarized in the tables below, which show the number of days required for the hatching of each female's eggs deposited on the 1st, 2nd . . . 8th day of oviposition. (See Tables 35, 36, 37, 38.)

For all of the four lots of Cecropias we find the duration of incubation to be from 12 to 16 days. As a rule one finds no variation due to their early or late deposition.

What a striking difference there is between the period of incubation of these four lots, with a mode of 14 days, and the lot of 1911, in which the period was only 6 to 11 days, with the mode at 8 or 9 days. We can account for the radical difference only by the fact that the eggs of the 1911 lot were laid a whole month later in the year than those of the present study. Inspection of the United States Meteorological Reports for these two periods when the eggs were incubating reveals that the mean temperature for June, 1911, was 79° F., while that of May, 1913, was 67.5°. So the cause of this difference may be only a matter of climatic conditions; the eggs laid at a warm time late in the season hatched much sooner than those exposed to the colder air earlier in the spring.

TABLE 35.

Period of Incubation. Eggs of S. cecropia. St. Louis, River des Peres, 1913, (Normal).

♀ No.	Day's Deposit							Date of 1st Day's Deposit
	1	2	3	4	5	6	7	
A	14	15	15	14	14	13	13	5-14
B	15	14	14	?	13	..	..	5-15
C	14	13	13	..	..	..	..	5-16
D	14	14	..	..	..	..	..	5-16
E	14	14	14	13	..	..	..	5-16
F	14	14	14	13	..	..	..	5-16
G	14	13	13	12	12	..	..	5-17
H	13	13	13	..	..	..	..	5-16
I	14	14	..	12	..	..	..	5-16
J	13	13	13	12	..	..	..	5-16
K	13	13	13	13	..	..	..	5-17
L	13	13	13	13	..	..	..	5-17
M	14	14	..	..	..	..	..	5-17
N	13	13	13	..	..	..	..	5-17
O	14	13	13	13	..	..	..	5-17
P	14	13	13	13	..	..	..	5-17
Q	14	13	13	12	..	..	13	5-17
R	14	13	..	..	..	..	..	5-17
S	14	?	12	..	..	..	..	5-17

TABLE 36.

Period of Incubation. Eggs of S. cecropia. St. Louis, River des Peres, 1913. (Fluffy).

♀ No.	Day's Deposit								Date of 1st Day's Deposit
	1	2	3	4	5	6	7	8	
A	15	14	15	14	14	15	..	..	5-11
B	14	15	14	14	14	14	14	..	5-12
C	14	15	14	14	14	14	14	14	5-12
D	14	15	14	14	14	..	..	..	5-12
E	15	14	14	14	14	14	14	14	5-13
F	14	15	14	14	14	14	..	..	5-14
G	14	..	..	..	..	..	..	..	5-15
H	15	14	..	..	..	..	..	..	5-15
I	14	..	..	..	..	..	..	..	5-15
J	15	14	14	14	12	..	..	..	5-15
K	14	?	14	..	..	..	..	..	5-16
L	14	14	14	14	..	..	..	..	5-16
M	?	?	?	?	12	..	..	..	5-17

TABLE 37.

Period of Incubation. Eggs of S. cecropia. South St. Louis, 1913.

♀ No.	Day's Deposit								Date of 1st Day's Deposit
	1	2	3	4	5	6	7	8	
A	16	15	14	13	14	14	14	14	5-10
B	15	14	14	14	..	..	..	..	5-12
C	14	14	14	14	..	..	..	..	5-13
D	15	14	14	13	13	13	..	..	5-15
E	15	14	14	14	13	..	..	..	5-15
F	14	14	14	14	..	..	..	..	5-15
G	14	13	13	13	..	..	..	..	5-16
H	15	14	13	13	..	..	..	..	5-16
I	14	13	13	..	..	..	..	..	5-17
J	14	?	?	12	12	..	..	..	5-17

TABLE 38.

Period of Incubation. Eggs of S. cecropia. New York, 1913.

♀ No.	Day's Deposit				Date of 1st Day's Deposit
	1	2	3	4	
A	15	14	15	14	5-15
B	13	12	..	..	5-18

TELEA POLYPHEMUS.

Owing to the difficulty in getting Polyphemus to mate in confinement, we have records on only 10 individuals of this species from the different localities. (See Tables 39, 40, 41.)

In this species too we see that the period of incubation is influenced by the date of oviposition. For instance, in Table 39 we have the eggs of 5 females laid in June; these have a period of 6 to 8 days. In this same table we have another lot of eggs deposited on May 20 which required 11 days. In Table 40 are the eggs from two insects, one's oviposition commencing on May 11 and the other on June 10; the earlier lot required 11 to 13

TABLE 39.

Period of Incubation. T. polyphemus. Augusta, Ga., 1913.

♀ No.	Day's Deposit				Date of 1st Day's Deposit
	1	2	3	4	
A	11	..	..	..	5-20
B	8	..	8	..	6-13
C	7	7	..	..	6-15
D	6	6	6	..	6-17
E	7	7	..	..	6-15
F	7	7	7	..	6-24

TABLE 40.

Period of Incubation. Eggs of T. polyphemus. Fall River, Mass., 1913.

♀ No.	Day's Deposit						Date of 1st Day's Deposit
	1	2	3	4	5	6	
A	11	11	13	12	13	13	5-11
B	10	9	8	8	9	..	6-10

TABLE 41.

Period of Incubation. Eggs of T. Polyphemus. St. Louis, 1912.

♀ No.	Day's Deposit				Date of 1st Day's Deposit
	1	2	3	4	
A	8	8	8	8	7-28
B	7	7	7	7	8-11

days, and the second, laid one month later in the season, took only 8 to 10 days. But more significant still, in reference to the influence of temperature upon incubation, are the two females listed in Table 41 which oviposited the last of July and the middle of August. The eggs of the first required but 8 days for developing, and the second only 7 days, the shortest period yet observed for Polyphemus eggs, and the latest in the season also.

SAMIA CALIFORNICA.

We could note the period of incubation of the ova of only 3 members of this species. (See Table 42.)

TABLE 42.

Period of Incubation. Eggs of S. Californica. Sonoma Co., Cal., 1912.

♀ No.	Day's Deposit					Date of 1st Day's Deposit
	1	2	3	4	5	
A	10	10	10	11	10	5-25
B	10	11	11	12	11	5-28
C	12	11	11	11	10	6- 1

Here the period of incubation was from 10 to 12 days for eggs deposited between May 25 and June 5.

PHILOSAMIA CYNTHIA.

We submit below the data on the period of incubation of the eggs of Cynthias from New York and Philadelphia. (See Table 43, 44, 45.)

The New York Cynthias emerged and oviposited earlier than those from Philadelphia. If we compare Tables 43 and 44 a little more closely we will observe that all of the eggs in which the period of incubation was from 10 to 12 days are at the top of the table, or among the eggs deposited June 3 to 12. Again when we look for the eggs which required only 8 or 9 days, we find them under the dates June 13 to 20. Now this first lot spent a period in development from June 3 to 28 inclusive, and the mean temperature for this period of 21 days was 75.8° F. The eggs of the latter lot were in incubation from June 13 to 29, for which period the mean temperature was 83°.

Hence in the Cynthias, as in all the other species here

TABLE 43.

Period of Incubation. Eggs of P. cynthia. New York, 1913.

♀ No.	Day's Deposit				Date of 1st Day's Deposit
	1	2	3	4	
A	11	12	..	..	6- 3
B	12	12	..	..	6- 6
C	12	..	..	..	6- 6
D	13	13	..	..	6- 9
E	14	..	..	..	6- 9
F	11	..	..	..	6- 9
G	12	12	..	..	6-10
H	?	10	10	..	6-11
I	11	?	10	9	6-11
J	9	..	..	..	6-12
K	9	10	..	..	6-12
L	10	10	9	..	6-12
M	11	?	9	9	6-12
N	10	9	10	..	6-13
O	9	9	..	..	6-13
P	9	9	..	..	6-13
Q	9	9	9	..	6-14
R	9	..	..	..	6-14
S	9	9	9	..	6-14
T	9	8	8	..	6-14
U	9	9	..	..	6-14
V	9	9	..	..	6-14
W	8	9	..	..	6-15
Y	9	..	..	..	6-18
Z	9	..	..	..	6-19

considered, it is clear that temperature conditions directly influence the period of incubation, the warmer days tending to accelerate the embryonic development and the cooler days to retard it.

Miscellaneous Data.

BASILONIA IMPERIALIS.

About 12 pupæ of *B. imperialis* were obtained in 1911, but 10 of them were parasitized by a large dipterous insect identified by Mr. Frederick Knab[17] as *Belvasia bifas-*

[17] Through the kindness of Dr. L. O. Howard.

TABLE 44.

Period of Incubation. Eggs of P. cynthia. Philadelphia, Pa., 1913.

♀ No.	1st Day's Deposit	Date of 1st Day's Deposit
A	8	6-17
B	9	6-17
C	10	6-17
D	9	6-17
E	8	6-18
F	9	6-18
G	10	6-19
H	9	6-19
I	9	6-20
J	9	6-20

TABLE 45.

Period of Incubation. Eggs of P. cynthia. New York, 1912.

♀ No.	Day's Deposit			Date of 1st Day's Deposit
	1	2	3	
A	8	8	9	7- 7
B	8	8	8	7-12

ciata Fab. Only one, a normal female, emerged May 28 and lived 8 days. The very evening of its first day it deposited infertile eggs. During its lifetime it laid 186 eggs and retained 10 after its death, making a total number carried of 196 eggs. One of the other chrysalides, when opened some time after all expectation of emergence was gone, was found to contain an adult moth, dead, which for some reason had not been able to effect the proper emergence. It was a female and it must have lived for some time, since 12 eggs had been deposited in this prison house.

PROBABLE TWO-BROODEDNESS OF T. POLYPHEMUS.

All of our Polyphemus adults—and a great number we had from several localities—emerged in May or June and one group emerged in good numbers as early as the last of April. Therefore we were much surprised to take a female on August 11, 1912, which was in good condition. The fact that she laid fertile eggs proves that there must also have been males lurking somewhere this late in the season. With what we know of the longevity of this species, it is impossible to believe this to be one which had emerged in the spring. This species may possibly be double-brooded.

On July 30, 1913, a male Polyphemus was brought to me, apparently in good condition.

INFERTILITY OF POLYPHEMUS EGGS.

Since the Polyphemus were seldom seen in copulo, it was thought that possibly mating might occur for such brief periods that it was only by chance that they could be seen. To test this point, all of the eggs of 25 females of this species which had had ample opportunity for mating were cared for until long past hatching time to see whether, perchance, fertilization had occurred unnoticed. But they all soon shrivelled, and none at all ever hatched. This strongly indicates that mating does not occur for brief intervals on the sly, and also that these females do not lay parthenogenetic eggs.

CROSSINGS.

On June 3 a female Polyphemus mated with a male Cecropia from 6 a. m. to 6 p. m. The female died the next day without ovipositing.

On May 9 a 10-day-old female Polyphemus mated with a male Cecropia. It lived for a few days afterward, and deposited 4 eggs, which proved infertile.

After we found it impossible to get the Prometheas to

mate in 1913, we selected a few cages containing a pair each and introduced into each one a male Cynthia. In four cases out of ten mating occurred, the female Promotheas giving preference to the Cynthia males—or perhaps yielding to their greater animation—and remained in copulo 24, 12, 10 and ? hours respectively. The eggs from these four matings were cared for, but all proved infertile.

June 8 a male Cecropia mated with a female Californica for 10 hours, but the eggs from this crossing also were infertile.

EATING OF EGG SHELLS BY T. POLYPHEMUS.

We found that when the Polyphemus larvæ remained prisoners in the vials in which they had hatched from the egg, they ate parts of many of the egg-shells. We do not know whether it is customary for Polyphemus to eat the shell after having emerged from it, or whether this is done only in the event of scarcity of other food. This practice was not indulged in by the Cynthias, Cecropias or Californicas.

CALLOSAMIA PROMETHEA.

While the Promethea experiments were in progress in 1911, almost every day at about 4 p. m. many free males were attracted to the laboratory by the females, and when they were placed inside the cages they lost very little time before mating. Unlike the Cecropia moth which mates just before dawn, the Promethea is in copulo before sunset, and while the Crecopia remains in mating on an average about 21 hours, this near relative continues for only 4 or 5 hours. The duration of copulation of the 18 pairs was as follows:

Hours in copulo	No. of pairs
Less than 1 hour	2
1 to 2 hours	2
2 to 3 hours	0
3 to 4 hours	4
4 to 5 hours	9
5 to 6 hours	1

In addition to these, many other pairs were left in copulo during the evening, but early the next morning they were found to have severed.

Judging from the short life of the Prometheas, and knowing that the Cecropia moths are mostly monogamous, we might almost assume that this species is also monogamous. From a small number of experiments this seems to be true, and in the case of all of the 24 females which mated, the males were allowed subsequently to remain in the cage. In these cases a second mating was never observed, although the usual period of mating is so short that mating could have occurred at a time when constant watching was impossible.

Some slight interest may be attached to the age of the insects when mating began, to see at how early or how late an age the moths were capable of mating.

Age	Females	Males
6 hours or less	1	1
6 to 12 hours	8	9
12 to 18 hours	1	0
18 to 24 hours	1	0
1 to 2 days	1	1
2 to 3 days	3	0
3 to 4 days	2	1
4 to 5 days	0	0
5 to 6 days	1	0

This table shows that 21 out of the 30 insects of both sexes mated before 24 hours of age.

FLUFFY CECROPIA COCOONS.

In 1911[18] we discussed the nature and abundance of the cocoons of *Samia cecropia*. During the past two years we have made additional observations which are interesting since they substantiate the earlier ones.

During the winters of 1912 and 1913 cocoons were gathered from the River des Pêres region, the same area as

---

[18] Psyche. 18: 168-170, 1911.

before. In the two lots the proportion of fluffy cocoons to compact ones was as follows:

Year	No. Fluffy	No. Compact	Total
1912-13	108	299	407
1913-14	27	285	312

These figures show that in 1912-13 the baggy cocoons occurred in, approximately, the proportion of 1 to 3 and in the following winter 1 to 10. Our previous work showed the proportion for 1910 to be 1 to 4, and for 1911, 1 to 6.

The sexes, recorded at the time of the emergence of the insects from the fluffy cocoons, were as follows:

Year	Males	Females	Total Observed
1912-13	44	35	79
1913-14	10	14	24

These notes again show that the fluffy cocoons are by no means rare, and that both sexes emerge from them. It is however of peculiar interest that not one fluffy cocoon was found in a lot of 300 cocoons from South St. Louis or the lot of 200 from New York.

We shall have to seek further for the factors controlling this fluffy condition. May it be that it is due to the mere fact that some larvæ are more vigorous than others, this greater vigor being due to the amount of food consumed, and that this greater vigor plus the surplus material in the body may express itself in the large weaving capacity?

DURATION OF PUPAL STAGE IN SAMIA CECROPIA.

Previously[19] we found the pupal period of *S. cecropia* to vary from 312 to 324 days. To this we wish to add the following data:

Sex	Spinning Completed	Emerged	Duration
♀	July 10, 1913	May 23, 1914	317 days.
♂	July 13, 1913	May 23, 1914	314 days.
♀	July 18, 1913	May 25, 1914	311 days.
♂	July 15, 1913	May 27, 1914	316 days.
♀	June 15, 1913	May 23, 1914	342 days.

[19] Psyche. 20: 204, 1913.

THE DURATION OF THE PERIOD OF COPULATION OF TROPAEA LUNA.

Notes were made on the time spent in copulo by four pairs of *T. luna*. One pair remained in copulo 5½ hours, two pairs for 6½ hours, and one pair for 9 hours.

COCOON SPINNING.

The following was the only note that could be made on the spinning of *S. cecropia*:

June 15, at 4 p. m., the cocoon was being commenced; just a few silken threads were spread over the insect. At 6 o'clock the next morning the cocoon covered the entire insect, but was so thin that the green caterpillar could be seen through it. By 4 p. m. the thickness had increased to such an extent that the insect could no longer be seen. So with a sharp knife a slice was cut off the side of the cocoon, making an opening about ½ by ¼ inch. Two hours later this was spun over; hence, the work was evidently still in progress on the inside of the cocoon.

SUMMARY.

1. We find that mating does not significantly lengthen or shorten the life of the males in any of the material observed.

2. In all of the groups studied the unmated females lived longer than the mated females.

3. In Polyphemus as a whole we find the females much longer lived than the males, and for the entire population the mean is much greater for the two southern localities, St. Louis and Augusta, than for the two northern regions, New York and Fall River.

4. In the Prometheas the mean length of life for the whole 1913 Fall River population is much longer than in the 1911 Crêve Coeur lot. Just the reverse exists in the Polyphemus from the two regions.

5. In the Cecropias we find the mean for the St. Louis population to vary from year to year between the extremes of 7.71 and 16.65 days.

6. By keeping Cecropias and Polyphemus in low temperatures the length of life is greatly prolonged.

7. The mean number of eggs carried by the five lots of Polyphemus varies from 198 to 293. In seven lots of Cecropias the mean varies from 195 to 344. The Prometheas show little difference in egg production despite the remote regions (Massachusetts and Missouri) from which they came.

8. In the Cynthias, Cecropias, Lunas and Prometheas the mated females oviposited more nearly completely than the unmated females.

9. A total of 3569 Saturniid cocoons gave 1879 males and 1690 females, or 111 males to 100 females.

10. The males emerged from 1 to 5 days ahead of the females in practically all of the material here considered.

11. We find no relation between the length of time spent in mating and the fertility of the eggs. We have cut the normal length of time of up to 24 or even more hours, to 2 hours without diminishing the fertility of the eggs. There is no relation between the fertility of the eggs and the order of their deposition.

12. The period of incubation of the eggs varies with the climatic conditions.

General Considerations and Conclusions.

In the previous paper we have reviewed fully the theories which have been advanced in an attempt to account for the duration of life. With material representing, as this does, only one small corner of the organic world, we cannot hope to formulate generalizations which would be applicable to all organisms, while to presume to build up entire theories upon the evidence in hand would be to repeat the error which has already

been too often committed of placing generalization before accurate and adequate investigation. It will be quite fitting, however, to take the few conclusive results gleaned from this detailed study and construct from them and around them a scheme which would systematize these factors in their relation to the propagation of this small group.

The very beginning of the adult life shows the simple adaptation to environment which is common to a large proportion of the members of the animal kingdom; their emergence is accelerated by high temperature early in the season or retarded by late cold. While this would be of advantage only to those species which are interested in vegetation, it is interesting to find the condition existing in these animals also which can have no concern for food, excepting for a food-plant upon which to deposit their eggs. In other words, they come out at warm periods, soon to wear themselves out, while they might live much longer if they came out during the colder days, since, as our experiments have shown, cool weather greatly prolongs a quiet life.

In practically all of this material we find the males emerging before the females. This may or may not be due to the fact that the females have the ova to produce; nevertheless, the males are on hand for the function of fertilization when the females appear, and hence this delicate adjustment of life, whatever its rise, is an advantage to the species, while it is of no help that we can now see to the individual.

The homologous length of life of the sexes harmonizes well with the monogamous habit which a large part, at least, of these insects follow. We must acknowledge that it is well for the species that the females are permitted as long a life as they have, in order that they may complete their long task of egg-laying. The males on the other hand have a comparatively long, useless period of life after mating. Since polygamy is known to exist in other species of this family, and in some here dealt with,

may it be that this group is now changing from polygamy to monogamy, and that some characteristics belonging to the former habit have not yet been pruned away?

When we go into the details of the longevity and oviposition of each individual we find many exceptions to this hypothetical principle of longevity as an adaptation for the benefit of the species; some are cut short in the midst of reproduction, while others continue an extended, useless life. But how do we know that this fine balance of longevity and oviposition is not interrupted by some of the details of environment, such as climate, moisture, etc.? May it be that these individuals which do not conform to this principle of the factors of longevity and oviposition are merely the ones which are doomed to probable elimination? Natural selection may now be at work building up these fine adjustments; those which conform to this principle are those which are surviving by the cumulative effects of their complete and abundant reproduction, while those contrary individuals may be the straggling element, always present in any population, undergoing elimination by their own failure to oviposit adequately.

In regard to the portion of the lifetime spent in copulo, it must be felt that here natural selection has not done refined work in having not reduced, during the phylogeny of the species, the time thus spent to a minimum in order to waste none of the allotted precious hours which the female has in which to oviposit.

In most cases we find the mated females depositing a greater per cent. of their eggs than the unmated individuals, while in every population they lived a shorter time than their unmated sisters. This longer life of the unmated female in every case might suggest that Nature is indicating in this way that it is the species rather than the individual that she cares for. Still their lease of life was sufficient to attend to this duty in the propagation of the species. This evidence harmonizes to a degree with Weissmann's theory of longevity being regu-

lated by natural selection for the good of the species, conserving the time which is an advantage to the race and curtailing useless existence.

In short, we must conclude that the longer or shorter life of these insects is due to physiological processes, but one must also admit that, regulating these physiological processes in some way, we have at work natural selection carefully seeing that these insects with aborted mouth parts have all of their ova at hand ready for ovipositing when they emerge from the cocoon, in addition to the proper amount of nutriment to give them sufficient length of life to deposit them, and this even though we know not whether the aborted mouth parts are due to the reserve nutriment or the reserve nutriment is there because of the aborted mouth parts.

Hence it would seem that our major problem is one not of physiological phenomena alone, nor of heredity of longevity alone, but a complex blending of these two factors such as can be raveled only by the analysis of large quantities of data on varied material.

EXPLANATION OF ILLUSTRATIONS.

In Figs. 1-8, the solid lines indicate males and the dotted lines, females.

Plate I.—Fig. 1. The emergence of 240 males and 213 females of *Philosamia cynthia*, New York and Philadelphia, 1913.—Fig. 2. The emergence of 46 males and 54 females of *Telea polyphemus*, St. Louis, 1913.

Plate II.—Fig. 3. The emergence of 101 males and 82 females of *Telea polyphemus*, Fall River, Mass., 1913.—Fig. 4. The emergence of 316 males and 287 females of *Telea polyphemus*, Augusta, Ga., 1913.

Plate III.—Fig. 5. The emergence of 54 males and 50 females of *Callosamia promethea*, Fall River, Mass., 1913.—Fig. 6. The emergence of 123 males and 113 females of *Samia cecropia*, South St. Louis, 1913.

Plate IV.—Fig. 7. The emergence of 76 males and 67 females of *Samia cecropia*, New York, 1913.—Fig. 8. The emergence of 331 males and 320 females of *Samia cecropia*, St. Louis, 1913.

Plate V.—Fig. 9. The emergence of 2237 Saturniid moths in relation to temperature. The solid line indicates all insects observed of both sexes; the broken line denotes temperature.

Issued December 22, 1914.

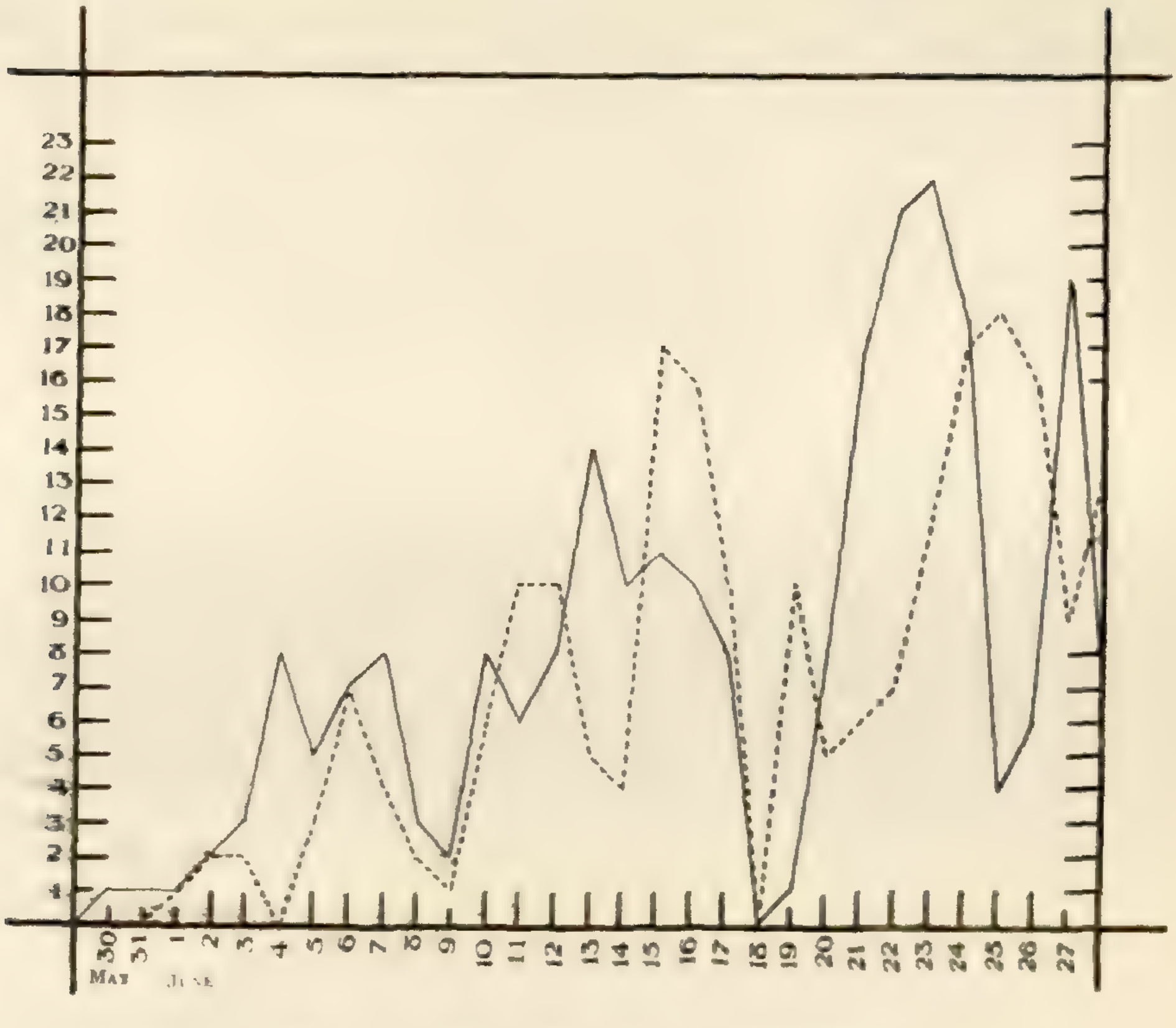


FIG. 1. PHILOSAMIA CYNTHIA

FIG. 2. TELEA POLYPHEMUS.

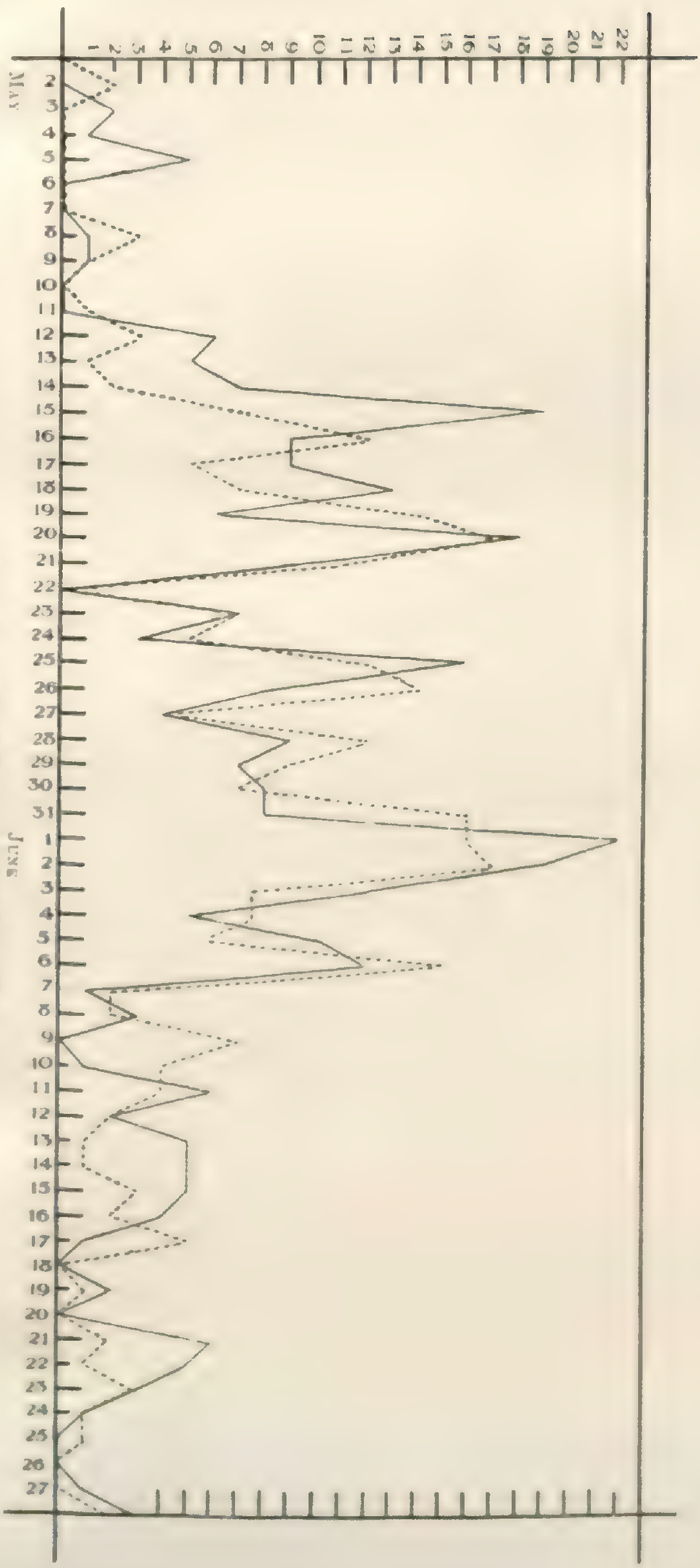


FIG. 1. TELEA POLYPHEMUS.

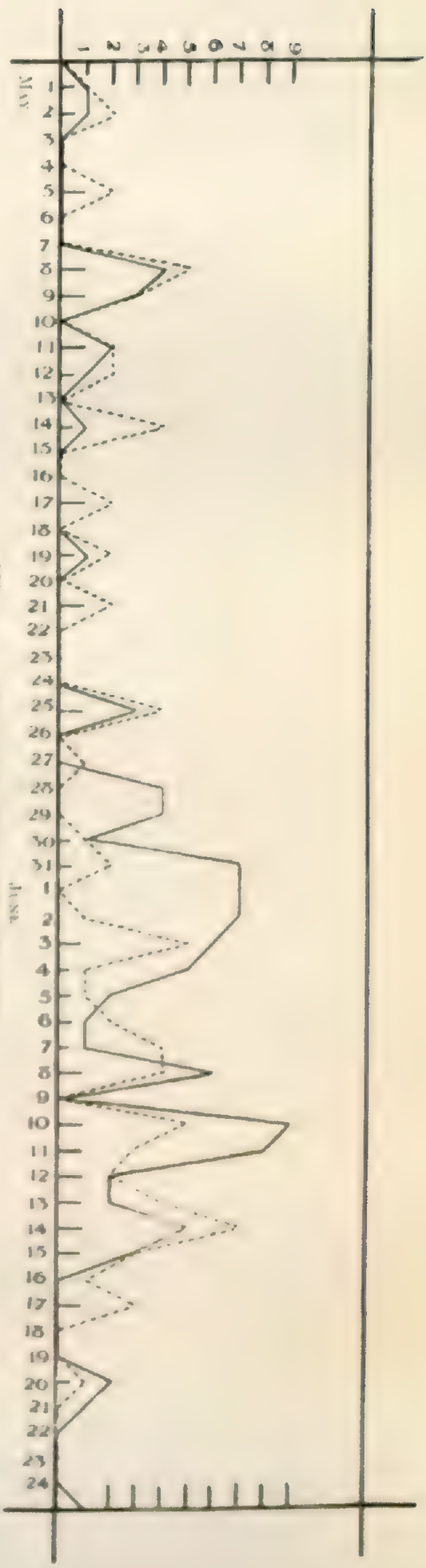


FIG. 3. TELEA POLYPHEMUS.

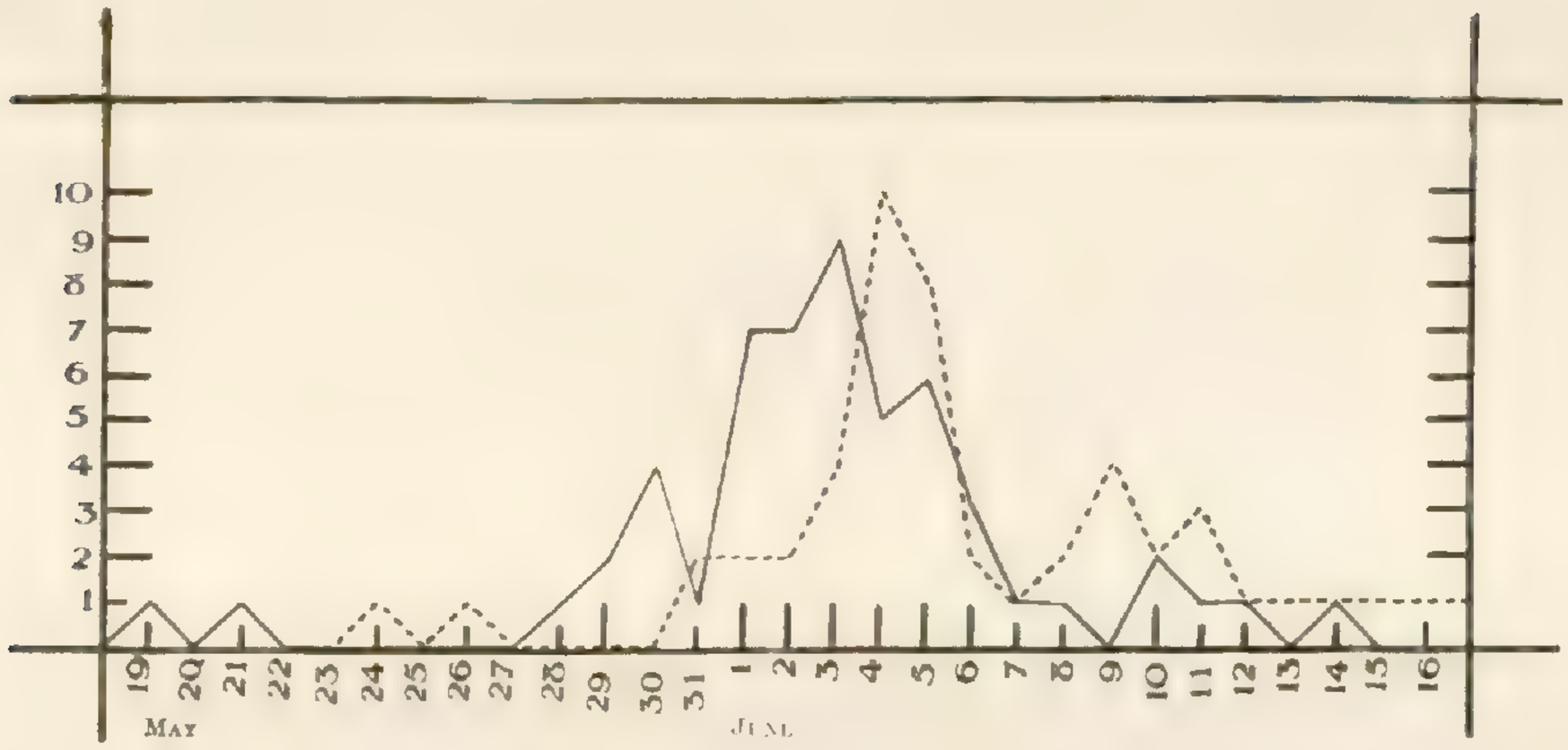


FIG. 5. CALLOSAMIA PROMETHEA.

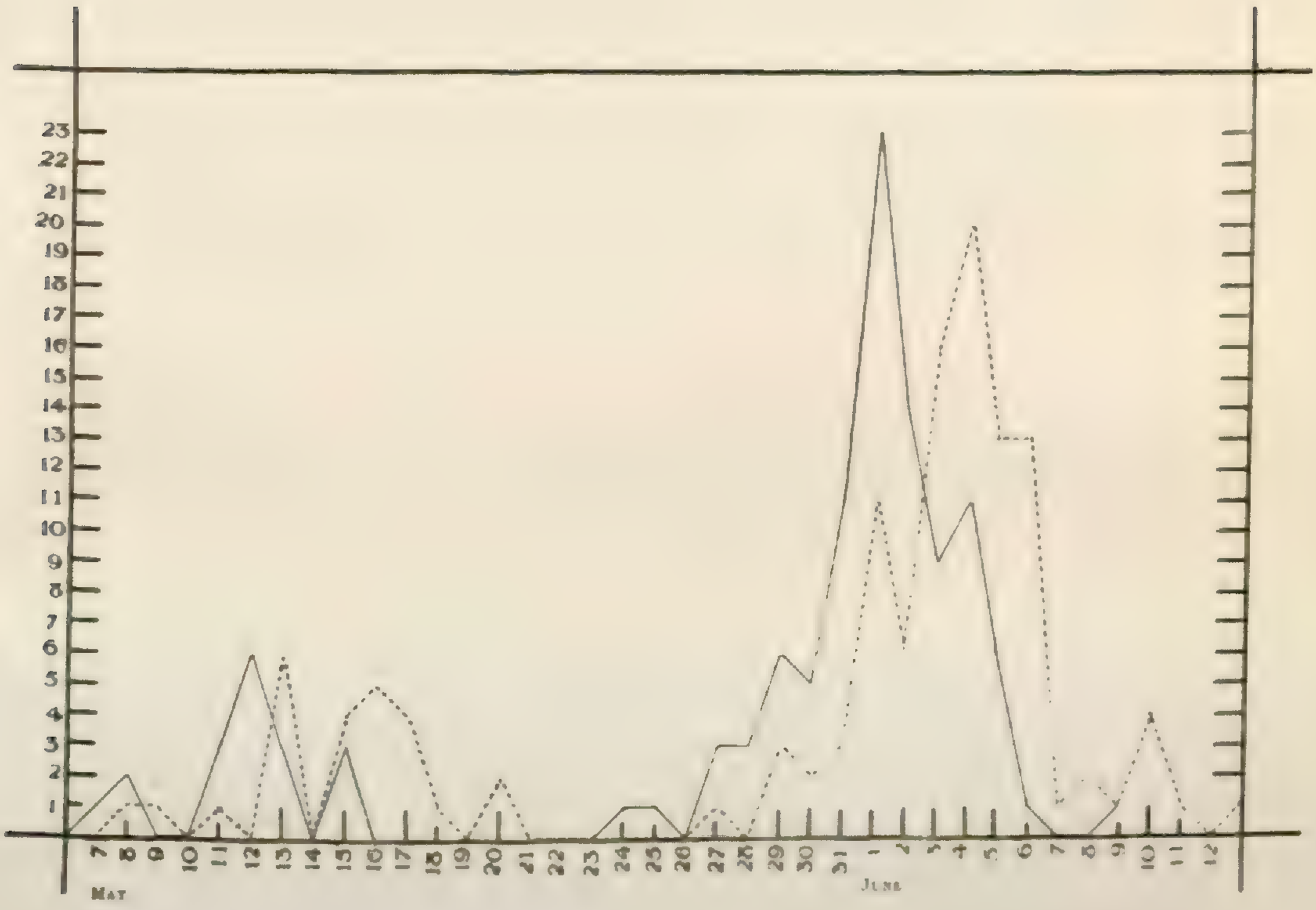


FIG. 6. SAMIA CECROPIA.

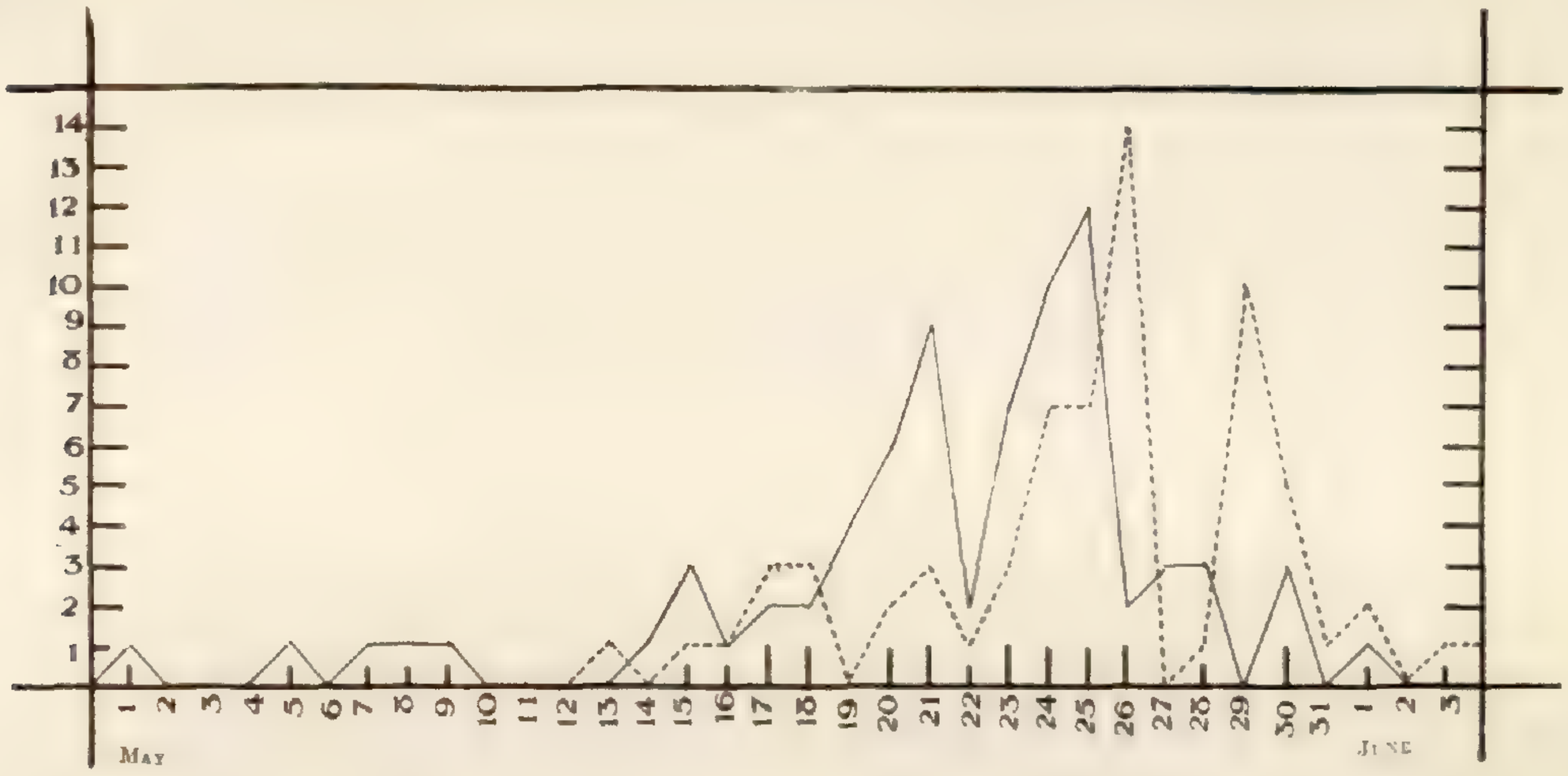


FIG. 7. SAMIA CECROPIA.

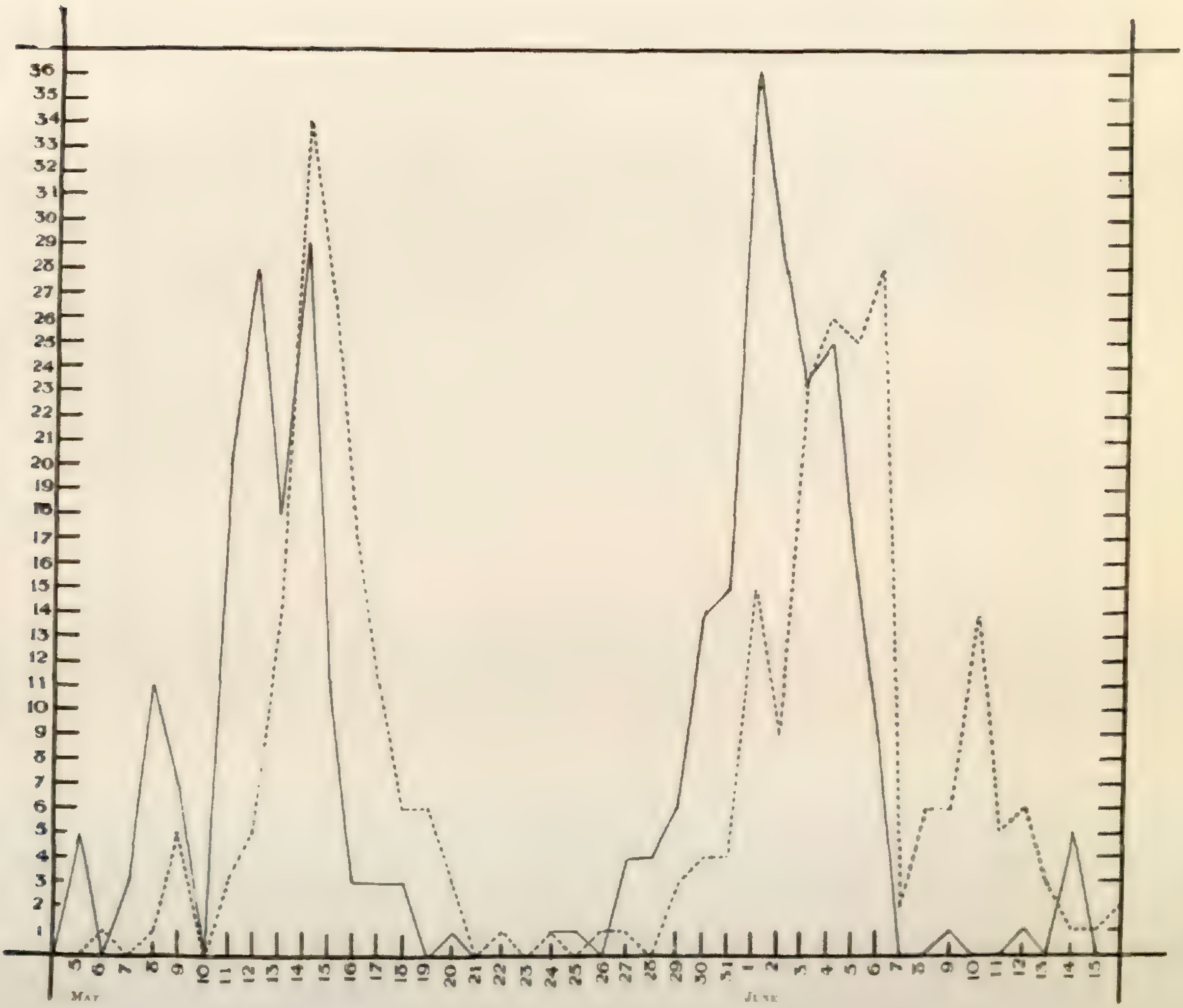


FIG. 8. SAMIA CECROPIA.

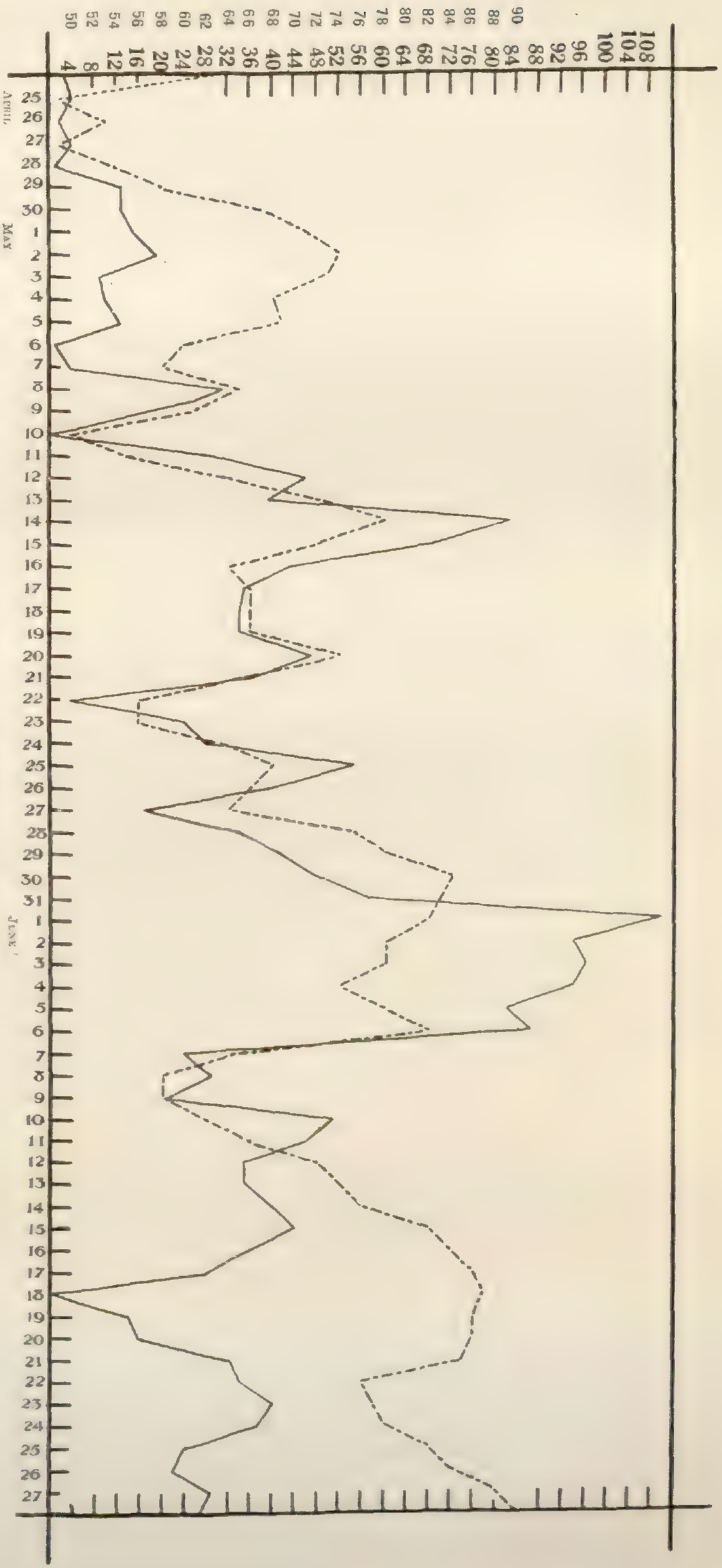


FIG. 9. SATURNIID MOTHS.

THE HISTORY OF SCIENCE IN ST. LOUIS.*

MARY J. KLEM.

The history of science in St. Louis extends back nearly to the time of its founding as one of the first settlements of Upper Louisiana one hundred and fifty years ago. The Jesuit missionaries, the great pioneers of the north and west, were the first white persons to visit the Mississippi Valley and the adjoining country, Father Marquette, the intrepid explorer, having been the first to pass the lonely forest that covered the site of the future city of St. Louis in the year 1673.

Fortunately the early missionaries were men of learning and observation. While they acquitted themselves faithfully of the duties of their calling, they recorded carefully the progress of events around them. The course of the Mississippi and the nature of the country were known to them and to the traders, who jointly with the missionaries carried on the discovery and exploration of the west. By the expeditions of Marquette, Jolliet, La Salle, Hennepin, and others, the Mississippi had been discovered and explored, opening to France the richest and most fertile territory of the new world.

André Michaux,[1] a distinguished French botanist,

---

* Read before The Academy of Science of St. Louis, May 18, 1914.

---

[1] Hooker, W. J. On the botany of America. Amer. Jour. Sci. and Arts. I. 9: 266-269. 1825.

Gray, Asa. Notes of a botanical excursion to the mountains of North Carolina. Amer. Jour. Sci. and Arts. I. 42: 2-9. 1842.

Sargent, C. S. Portions of the journal of André Michaux, botanist, written during his travels in the United States and Canada, 1785 to 1796. With an introduction and explanatory notes. Proc. Amer. Phil. Soc. 26: 1-145. 1889.

Thwaites, R. G. André Michaux's travels into Kentucky, 1793-96. Early Western Travels 1748-1846. 3. 1904.

Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. 1908: 488-491.

and one of the most interesting and picturesque figures in the annals of botanical discovery in America, may be said to have been the first scientist to visit the vicinity of St. Louis. Before coming to America, Michaux had, in the interests of science, traveled in France, England and the Orient. He came to the United States in 1785 at the request of the French government to study the forest trees and experiment with regard to their transplantation to France. In the course of his travels in North America Michaux explored the mountains of the Carolinas, journeyed through the hazardous swamps and marshes of Florida, visited the Bahamas, crossed the Alleghanies in his search for new plants, and in 1795-96 made a journey from Charleston, S. C., through Tennessee, Kentucky and Indiana, to Kaskaskia, Cahokia and vicinity. Most probably he visited the western shore of the Mississippi. In his "Flora Boreali Americana" he records several species of plants as coming from the Missouri river. This is no positive proof, however, of his having collected west of the Mississippi, as the plants might have been given to him while he was at Cahokia. He mentions St. Louis as a prosperous settlement, but makes no further allusion to it.

Looking back through the vista of years, we find picturesque and interesting incidents shaping the early history of St. Louis, when around it and far to the west stretched an unbroken wilderness into which the white man had scarcely penetrated. One of the central figures in the little French village in the year 1800 was Dr. Antoine François Saugrain—scientist, physician and chemist. Although he was not the first to practice medicine here, he was the most notable of the early representatives of the profession because of his broad learning and scholarly attainments.

Dr. Saugrain[2] was educated as a physician and chem-

[2] Bliss, E. F. Dr. Saugrain's relation of his voyage down the Ohio river from Pittsburgh to the Falls in 1788. Proc. Amer. Ant. Soc. 11: 369-380. 1897.

ist. Entering the service of the king of Spain, he was sent to Spanish America about 1783 to examine the geological formations of the country and its fauna and flora. After a visit to Paris he returned to America and in 1787 explored Kentucky and the country along the Ohio river, writing an interesting account of the adventures that befell him and his companions on this expedition. After enduring almost incredible hardships from fatigue, exposure, hunger, and the attacks of hostile Indians, Dr. Saugrain and his companions reached the Falls of the Ohio. After recovering from wounds he had sustained, the Doctor made an examination of the soil and its natural products, particularly the mineral deposits and salt licks. Proceeding up the Ohio on a flat boat to Fort Pitt, now Pittsburg, he crossed the mountains to Philadelphia, where he was received by Franklin.

Returning to France, Dr. Saugrain remained there until 1792 or 1793, when he sailed again for the United States with a company of French colonists, who located at Gallipolis, Ohio. For various reasons the colonists became dissatisfied and most of them moved elsewhere. Dr. Saugrain went to Lexington, Ky., probably in 1796 or 1797, and the following year visited St. Louis. Being much pleased with the place and the people, he brought his family to live here in 1800.

He seems to have been both popular and successful as a physician, but preferred chemistry to medicine, and devoted all of his leisure time to it. Dr. Saugrain probably had the first laboratory in St. Louis. A contemporary of his says: "Many of my countrymen used to

---

Dandridge, N. P. Antoine François Saugrain (De Vigni) "The first scientist of the Mississippi valley." Jour. Amer. Med. Assoc. **43**: 2007-2011. 1904.

Goodwin, E. J. Antoine François Saugrain. A history of medicine in Missouri. 19-21. 1905.

Bliss, E. F. Dr. Saugrain's note-books. Proc. Amer. Ant. Soc. **19**: 221-238. 1908.

Byars, W. V. The first scientist of the Mississippi valley. A memoir of the life and work of Doctor Antoine François Saugrain. n. d.

come and stare at his doings, which they were half inclined to think had too near a resemblance to the black art. The doctor's little phosphoric matches, igniting spontaneously when the glass tube was broken, were thought by some to be rather beyond mere human power. His barometers and thermometers, with the scale neatly painted with the pen, and the frames richly carved, were objects of wonder."

In his medical practice he depended largely upon herbs which he grew in the garden surrounding his house or gathered in the wild state. The first case of smallpox in St. Louis appeared the year after Dr. Saugrain came. He was an advocate of vaccination, calling attention to its value as a preventive of smallpox and announcing his readiness to vaccinate any one who should apply. He was made post physician under the Spanish lieutenant governor, Don Carlos Dehault Delassus, and, when this section of the country became United States territory, he was reappointed by President Jefferson. Until his death, which occurred in 1820, Dr. Saugrain continued his scientific experimental work and practiced his profession as a frontier physician. He was the first notable representative of scientific investigation in St. Louis and this part of the country.

All the early explorers of the interior of North America dreamed of a passage to the South Sea and of a new road to reach China and Japan with a view to entering into commercial relations with these countries. From the Indians they had learned of a great river flowing into the ocean far away. The theory of a short-cut transcontinental waterway was believed practicable by the French throughout their occupancy of North America. Jolliet and Marquette thought that the Mississippi might flow into the Pacific ocean, but on ascertaining that this was not the case, they looked upon the Missouri river as the one flowing into the Ocean of the West. Several French expeditions were organized to explore the Missouri and some of its lower tributaries, but they ac-

complished very little beside exploring the country for a few hundred miles above its mouth.

In 1783 a proposition was made by Jefferson to George Rogers Clark "for exploring the country of the Missisipi to California," but the expedition was never undertaken. Three years later Jefferson arranged with the adventurous John Ledyard of Connecticut, who had been with Captain James Cook on his third voyage around the world, to penetrate the Missouri river from the west by crossing Europe and Asia to Kamchatka and thence in a Russian trading vessel to Nootka Sound. From there he was to find his way to the sources of the Missouri and descend that stream to the American settlements. This enterprise came to grief when Ledyard was arrested in Kamchatka by agents of the Russian crown. Captain John Armstrong in 1790 attempted to ascend the Missouri under orders from the War Department, but failed because of the hostility of the Missouri Indian tribes. In 1793, Jefferson, as vice-president of the American Philosophical Society—then almost the only organization for the encouragement of scientific study in America—dispatched upon this same mission André Michaux, the distinguished French botanist, who, however, tarried in Kentucky to conduct a French political intrigue, with the result that his project of exploration was abandoned.

When Jefferson became President of the United States he did not forget his early dreams of exploring the Far West, and dispatched Lewis and Clark,[3] the first im-

---

[3] Jefferson, Thomas. Biography of Captain Lewis. Anal. Mag. and Naval Chron. 7: 329-333. 1816.

Allen, Paul. History of the expedition under the command of Captains Lewis and Clark. 1814. Reprint New Amsterdam Book Company.

Coues, Elliott. History of the expedition under the command of Lewis and Clark. 1893.

Greely, A. W. Captain Meriwether Lewis and Lieut. William Clark, first trans-continental explorers of the United States. Men of Achievement. Explorers and Travellers. 105-162. 1893.

portant government expedition that was sent out to explore the great unknown mountain regions of the extreme west. This expedition, starting from St. Louis, proceeded up the Missouri river in May, 1804, and, after spending the winter among the Mandan Indians, not far from the present city of Bismarck, North Dakota, resumed the journey in April, 1805. From the head waters of Jefferson Fork they crossed the snow-clad Bitterroot Mountains, and descended the foaming rapids and cataracts of the Columbia river to the Pacific coast. On the return trip Lewis explored the Falls of the Missouri and Maria's river, while Clark and his party descended the Yellowstone to its junction with the Missouri. The final happy arrival of the re-united parties in St. Louis in September, 1806, is one of the familiar events of American history.

From a geographical point of view this expedition was a great and successful achievement, Lewis and Clark having fixed pretty well the positions of the Missouri and Columbia rivers. Every item of information which they secured was a new acquisition to history and science. However, the absence of scientific men from the expedition was seriously felt when the reports were made up from the data at hand. Many discoveries had been made in natural history, but no member of the party being competent to determine their scientific value, Lewis and Clark did not receive the credit for priority of discovery to which they were entitled. The antelope, black-tailed

---

Thwaites, R. G. A brief history of Rocky mountain exploration with special reference to the expedition of Lewis and Clark. 1904.

Thwaites, R. G. Original journals of the Lewis and Clark expedition 1804-1906. 1904.

Wheeler, O. D. The trail of Lewis and Clark 1804-1904. 1904.

Smith, W. R. General William Clark, Territorial governor of Missouri. Bull. Washington Univ. Assoc. 4: 46-69. 1906.

Thwaites, R. G. William Clark: Soldier, explorer, statesman. Mo. Hist. Soc. Coll. 2: 1-24. 1906.

Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. 1908: 492-493.

deer, mule deer, prairie dog, and grizzly bear were unknown to science until discovered by the Lewis and Clark expedition, the grizzly bear being the most notable discovery made in zoology by Lewis and Clark.

Upon their return to St. Louis the leaders of the expedition began at once to write out their notes for publication. However, both were soon called to high office—Lewis being made governor of the Louisiana Territory, and Clark appointed superintendent of Indian affairs.

Clark made St. Louis his home during the remaining years of his life. He expended much time and effort in establishing an Indian Museum, the first collection of Indian weapons and curiosities in the country, which for a long time was one of the interesting sights in St. Louis to visitors. The Duke of Saxe-Weimar Eisenach, who visited this country in 1825 and 1826, in his "Travels Through North America," gives an extensive description of this interesting museum, from which I quote the following paragraph:

"We then went to see Mrs. Clark, who, through the secretary of her husband, Mr. Alexander, exhibited to us the museum collected by the governor on his travels, and since considerably augmented. Mr. Alexander showed us articles of Indian clothing of different kinds, and various materials. Except the leather, the larger part of these materials were American, or rather entirely European in their origin. A single garment alone was made by the Cherokees of cotton, which was pulled, spun, wove on a loom, made by the Indians, and even dyed blue by them. Besides, several weapons of different tribes, wooden tomahawks, or battle axes; in one of them was a sharp piece of iron to strike into the skulls of their prisoners; another made of elk's horn; bows of elk's horn and of wood; spears, quivers with arrows; a spear head of an Indian of the Columbia river, hewed out of flint; a waterproof basket of the same people, in which cooking can be performed; several kinds of tobacco pipes, especially the calumet, or great pipe of peace. The head of this pipe is cut out of a sort of argillaceous earth, or serpentine; in time of war, the spot where this earth is dug out, is regarded as neutral, and hostile parties, who meet each other at that place, cannot engage in anything inimical against each other. The pipe which the commissioners of the United States use at treaties with the Indians, has a heavy silver head, and a peculiarly handsome ornamented wooden stem. Farther: Mr. Alexander showed us the medals which the Indian chiefs have received at different periods from the Spanish, English and American governments, and the

portraits of various chiefs, who have been at St. Louis to conclude treaties with the governor, who is also Indian agent. Among the remarkable things in natural history, we noticed an alligator, eight feet long; a pelican; the horns of a wild goat, shot by the governor in his tour among the Rocky Mountains; the horns of a mountain-ram and those of an elk; several bearskins, among others, of the white bear; buffalo, elk and skunk, which were sewed together in a robe; skins of martins, ferrets, etc., etc. Moreover, several petrifications of wood, and animal subjects, among others, of elephant's teeth; a piece of rock-salt, tolerably white, yet not shooting in crystals, as the English; various crystals; a large piece of rock crystal; very handsome small agates, which are here taken for cornelians, etc. Among the curiosities, the most remarkable were two canoes, the one of animal-hide, the other of tree-bark; a peace-belt, which consists of a white girdle, set with glass beads two hands breadth wide; farther, snow shoes; nets which are drawn over an oval frame; also the rackets, which they use in playing their game of ball, etc., etc."

Soon after the purchase of Louisiana steps were taken by the government to explore the then unknown wilds of our western country. The name of Zebulon Montgomery Pike[4] will always be associated with those of Lewis and Clark in the history of early explorations beyond the Mississippi. Pike's expedition to the source of the Mississippi and his expedition to the sources of the Arkansas river and the Rocky Mountains of Colorado were the first military and the second governmental explorations which penetrated to any considerable extent our newly acquired territory of Louisiana.

In July, 1805, Pike was ordered to explore and report upon the Mississippi river from St. Louis to its source,

---

[4] Pike, Z. M. An account of expeditions to the sources of the Mississippi, and through the western parts of Louisiana, to the sources of the Arkansas and Pierre Jaun rivers, performed by order of the government of the United States during the years 1805, 1806, and 1807; and a tour through the interior parts of New Spain, when conducted through these provinces by order of the Captain General, in 1807. 1810.

Whiting, Henry. Life of Z. M. Pike. Spark's Lib. Amer. Biog. 5: 219-317. 1848.

Greely, A. W. Zebulon Montgomery Pike, explorer of the sources of the Mississippi and Arkansas rivers. Men of Achievement. Explorers and Travellers. 163-193. 1893.

Coues, Elliott. The expeditions of Zebulon M. Pike. 1895.

select sites for military posts, treat with the Indians, and find out what he could about the British traders who still occupied posts in our newly acquired territory. Navigating his boats to the vicinity of the present Little Falls, he proceeded onward by land as far as the mouth of Turtle River. He had an idea that the source of the Mississippi was somewhere near this river, but, owing to the extremely cold weather, he did not push beyond the mouth of the Turtle River and returned to St. Louis in April, 1806.

In July, 1806, Pike left St. Louis on his second expedition to the southwestern part of Louisiana Territory. While near the present site of Pueblo, Colorado, he made an unsuccessful side trip which had for its object the ascent of the since famous peak which bears his name.

Captain Chittenden in his classic history of the American Fur Trade of the Far West says: "It is doubtful if history affords the example of another city which has been the exclusive mart for so vast an extent of country as that which was tributary to St. Louis during the entire period embraced in this work. (1807-1843.) Every route of trade or adventure, to the remote regions of the west centered in St. Louis. The very location at the mouth of the Missouri gave it monopoly of all trade originating in the valley of that stream, whether among the wild tribes of the mountains three thousand miles away, or among the infant settlements which were advancing with slow but sure foot-step along the lower course of the river. The Oregon Trail, which began as an independent line of travel, near the present site of Kansas City, Mo., brought down the tribute from the high mountain sections of the central west, from the interior basin of the Great Salt Lake, and to some extent from the more remote regions on the Pacific slope. In like manner the Santa Fe Trail, which left the Missouri river at the same point as did the Oregon Trail, and was coincident with it for some distance west, carried to and fro that peculiar commerce which long existed with the for-

eign city of Santa Fé, and even with the distant provinces of old Mexico and of southern California."

"It was here that trans-shipment of commerce was made to eastern markets by way of the Mississippi, the Ohio, or the Great Lakes. Warehouses and mercantile establishments arose for outfitting the numberless expeditions to the interior. The government maintained a military post near by, and had here its principal office of Indian affairs for the trans-Mississippi tribes."

"The cause of science has repeatedly acknowledged its indebtedness to the fur trade. Maximilian, Nuttall, Audubon, Nicollet, Catlin, and many others enjoyed facilities for work in that wild country which would have been impossible without the assistance of the trader. This was particularly true of those researches which related to the early life, customs, and tribal history of the Indians; to the fauna and flora of the country; and to the geography of a region which was *terra incognita* when the trader entered it."

The Missouri Fur Trading Company, which owed its success to the great ability and energy of Manuel de Lisa; the Rocky Mountain Fur Company, whose guiding spirit was the brilliant and enterprising General W. H. Ashley; and the American Fur Company, with Pierre Chouteau, Jr., as the capable St. Louis partner of John Jacob Astor, conducting its affairs; these and many other companies too numerous to mention here, were most liberal toward scientific expeditions going up the Missouri and contributed in no small degree to their success.

In 1811 John Jacob Astor[5] launched his famous en-

---

[5] Irving, Washington. Astoria; or, Anecdotes of an enterprise beyond the Rocky Mountains. 1836.

Ross, Alexander. Adventurers of the first settlers on the Oregon or Columbia river; being a narrative of the expedition fitted out by John Jacob Astor to establish the "Pacific fur company," with an account of some Indian tribes on the coast of the Pacific. 1849.

Franchère, Gabriel. Narrative of a voyage to the northwest coast

terprise, which contemplated the organization of the fur trade from the Great Lakes to the Pacific and by way of the Sandwich Islands to China and India. He founded at the mouth of the Columbia river a settlement, named Astoria, which was to serve as a central depot. However, this gigantic undertaking was frustrated through a series of disasters and Astoria seized and occupied by the British in 1812. To carry out his scheme, Mr. Astor organized two expeditions, one to go by sea and the other by land along the route followed by Lewis and Clark. The overland expedition left St. Louis under the leadership of Wilson P. Hunt, of St. Louis. Two naturalists availed themselves of this opportunity to visit the upper Missouri, John Bradbury and Thomas Nuttall.

Bradbury[6] had been commissioned in 1809 by the Botanical Society of Liverpool to make some researches into the plant life of the United States. It was then quite the fashion among botanists to collect living plants and cultivate them in gardens, many eventually finding their way to Europe.

Arriving in this country during the summer of 1809, Bradbury, having letters of introduction to Jefferson, visited the latter at Monticello. Acting upon Jefferson's advice, he decided to make St. Louis the center of his explorations instead of New Orleans, as he had originally intended. He arrived in St. Louis on the last day of 1809, and, after the necessary inquiries and prepara-

---

of America in the years 1811, 1812, 1813, and 1814; or, The first American settlement on the Pacific. 1854.

Chittenden, H. M. The American fur trade of the far west. 1: 163-246. 1902.

[6] Bradbury, John. Travels in the interior of America in the years 1809, 1810, and 1811. 2nd ed. 1819.

Short, C. W. Transylvania Jour. Med. 34: 12-13. 1836.

Britten, Jas., and Boulger, G. S. Biographical index to British and Irish botanists. 21. 1893.

Thwaites, R. G. Bradbury's travels in the interior of America 1809-1811. Early Western Travels 1748-1846. 5: 1904.

Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. 1908: 493-495.

tions, he spent the spring and summer of 1810 making short excursions within a radius of eighty to a hundred miles from St. Louis. In this manner he made an exhaustive study of the natural history of this vicinity, and gathered many living specimens, which he forwarded to Liverpool. Besides studying the plants in the vicinity of St. Louis quite thoroughly, Bradbury explored the coal and lead mines, described the sink holes and fossil remains within twenty miles of the city, and advocated the manufacture of saltpeter from the niter found in the neighboring caves.

Bradbury had intended to remove to the Arkansas river, when, early in 1811, he met at St. Louis the leaders of the overland Astorian expedition and gladly availed himself of their invitation to accompany them. Nuttall,[7] with eagerness, had also embraced this opportunity to gratify his ardent desire for distant travel and his passion for the study of Nature. They journeyed with the traders for eighteen hundred miles to the fur trading station among the Mandans. During their journey they experienced many hardships and were in constant danger of losing their lives, being pursued and robbed by the Indians. Bradbury fell into their hands and only saved his life by taking his watch to pieces and distributing the works among the Indians. Nuttall, overcome by fatigue and hunger, and driven to despair in the wilderness, laid down and would inevitably have died, had he not been found by a friendly Indian, who placed him in his canoe and rowed him down the Missouri river to the

---

[7] Short, C. W. Transylvania Jour. Med. 34: 14-16. 1836.
Durand, Elias. Proc. Amer. Phil. Soc. 7: 297-315. 1860.
Meehan, Thos. Gardeners' Month. 2: 21-23. 1863.
Britten, Jas., and Boulger, G. S. Biographical index of British and Irish botanists. 129. 1893.
Pop. Sci. Month. 46: 689-696. 1895.
Youmans, W. J. Pioneers of Science in America. 205-214. 1896.
Harshberger, J. W. Botanists of Philadelphia. 151-159. 1899.
Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. 1909: 52-57.

first white settlement. Nuttall returned to Philadelphia with many and various species of plants and seeds, with many valuable specimens of minerals and other objects of natural history.

Bradbury, upon his return to the Arikara village, found the Astorians in active preparation for their journey across the continent by land. He was invited to accompany them to the coast, but on account of his large collections and the uncertainty of obtaining tranportation by sea, he preferred to return to St. Louis with Henry M. Brackenridge in one of the boats belonging to Manuel Lisa, a prominent fur trader of St. Louis.

Having finally returned to Liverpool in 1815, Bradbury published in 1817 a book on his Travels in the Interior of America, 1809-1811. In the preface to the second edition of 1819 it is stated that Mr. Bradbury has taken up his permanent residence in St. Louis. He was visited by the members of Long's Expedition at his home at Sulphur Springs, in the valley of the River des Peres, not far from what is now Cheltenham. His name is given in the city directory for 1821, but it does not appear in subsequent issues and no further information has been obtainable of his whereabouts.

Another naturalist who visited this section of the country early in the nineteenth century was Henry Rowe Schoolcraft,[8] a conspicuous figure among the scientists of the early part of the century. To him we are indebted for the first account of the geological formations of the great valley beyond the Alleghanies and of its mineral wealth and resources. We are also indebted to him for the discovery of the source of the Mississippi river in Itasca lake. For many years, beginning with 1817, he

---

[8] Henry Rowe Schoolcraft. Annals of Iowa. 1865: 498-505.
Henry Rowe Schoolcraft. Amer. Geol. 5: 1-9. 1890.
Youmans, W. J. Henry Rowe Schoolcraft. Pioneers of Science in America. 300-310. 1896.
Williams, M. C. Henry R. Schoolcaft. Mo. Hist. Soc. Coll. 2: 45-47. 1903.

stirred up interest in natural history from one end of the land to the other, and after his settlement in the west he was readily accessible to scientists and travelers.

Schoolcraft was a geologist, who did considerable special work in mineralogy, then an almost unknown science in the United States, and studied the phenomena of meteorology. He was a great traveler, always on errands of scientific interest, an enthusiastic student of archæology, and was particularly known as an investigator and standard authority in all that pertained to the ethnology of the North American Indian.

In 1817 he decided to study the topography, geology and mineralogy of the Mississippi Valley, as well as its ethnology. This offered great opportunities on account of its curious mounds, its antiquities and existing Indian tribes. The localities he explored were principally in Missouri, and Schoolcraft's name is indelibly linked with the natural history of this state. From Pittsburg he journeyed down the Ohio river to its mouth and up the Mississippi to St. Louis, traveling at the rate of five or six miles a day. While the men poled the barges he explored the country west of the Mississippi, which is noted for its mines. It took him about three weeks to reach Herculaneum, and for the remaining thirty miles to St. Louis he tramped through the woods and over the hills, noting in his journal every peculiar topographical feature. Schoolcraft was greatly pleased with St. Louis, being particularly interested in the private museum of Governor Clark.

He did not stay very long in the city, but moved to Potosi, which he made the center of his investigations in the mining regions of that district. Having made a very minute mineralogical study of the region, and wishing to ascertain its geological connection with the Ozarks and neighboring mountains, he explored the southwestern part of Missouri and Arkansas.

After 1811 no scientific expeditions penetrated the Far

West until 1819-20, when Major Stephen H. Long[9] and his corps of scientists made their famous explorations.

From the reports of trappers, topographers had begun to suspect that the Platte river might possibly flow from some pass in the center of the Rockies, more accessible and more practicable than the round-about and difficult path of Lewis and Clark and the Astorians to the Pacific. In 1819 Major Stephen H. Long, a topographical engineer, who had made trips to the Red and Washita rivers in 1817-18, was sent by President Monroe to discover, if possible, this desirable South Pass, and on his return to make an attempt to determine the source of the Red river.

As originally planned, the scientific observations were to be conducted by a company of specialists under the command of Major Long. Among his associates were Dr. William Baldwin,[10] the botanist, who terminated his labors and his life on this expedition at Franklin, Mo.; Dr. Edwin James[11], Dr. Baldwin's successor, who is best

---

[9] Chittenden, H. M. The American fur trade of the far west. 2: 562-587. 1902.

Thwaites, R. G. Edwin James's Account of an expedition from Pittsburgh to the Rocky Mountains, performed in the years 1819, 1820. By order of the Hon. J. C. Calhoun, Secretary of War, under the command of Maj. S. H. Long, of the U. S. Top. Engineers. Early Western Travels 1748-1846. 14-17. 1904.

[10] Darlington, Wm. Reliquiae Baldwinianae. 1-346. 1843.

Redfield, John. Dr. William Baldwin. Bot. Gaz. 8: 233-237. 1883.

Harshberger, J. W. William Baldwin. Botanists of Philadelphia. 119-125. 1899.

Thwaites, R. G. Edwin James's account of an expedition from Pittsburgh to the Rocky Mountains, performed in the years 1819, 1820, by order of the Hon. J. C. Calhoun, Secretary of War, under the command of Maj. S. H. Long, of the U. S. Top. Engineers. Early Western Travels 1748-1846. 14: 39. 1904.

Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. 1908: 495-497.

[11] Parry, C. C. Dr. Edwin James. Amer. Jour. Sci. and Arts. II. 33: 428-430. 1862.

Thwaites, R. G. Edwin James's account of an expedition from Pittsburgh to the Rocky Mountains, performed in the years 1819, 1820, by order of the Hon. J. C. Calhoun, Secretary of War, under the com-

known among scientific men in this countury as the botanist and historian of this expedition, and who made the first ascent to the summit of Pike's Peak on July 14, 1820; Dr. Thomas Say,[12] the zoologist; and Dr. A. E. Jessup,[13] the gelogist.

While this expedition did not accomplish either of the great objects for which it was sent out—the discovery of the sources of the Platte and the Red rivers—the work of the scientists was, however, of great value, inasmuch as it added to our knowledge of a part of the country which was hitherto but imperfectly known through hunters and traders. This applies especially to the discoveries made in natural history and ethnology.

Before leaving St. Louis, Long's party made some local investigations. Dr. Say examined some of the sink holes around St. Louis, descending into one of them for the purpose of ascertaining the mean temperature below the surface of the earth. On the grassy plains to the west of St. Louis Dr. Baldwin found many beautiful plants, among them *Aristolochia sipho* (the Dutchman's pipe), *Cypripedium spectabile and parviflorum* (Lady slippers), *Lilium catesbeiana* (Red lily), *Triosteum perfoliatum* (Horse gentian), *Clematis virna* (Virgin's bower, and *Tradescantia virginica* (Spiderwort). Dr. Say went down the river to the mouth of the Meramec and up that stream about fifteen miles. He had been told of the discovery of many graves in that locality said to contain skeletons of a diminutive race. In one

---

mand of Maj. S. H. Long, of the U. S. Top. Engineers. Early Western Travels 1748-1846. 14: 40. 1904.

Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. 1908: 497-498.

[12] Youmans, W. J. Thomas Say. Pioneers of Science in America. 215-222. 1896.

[13] Thwaites, R. G. Edwin James's account of an expedition from Pittsburgh to the Rocky Mountains, performed in the years 1819, 1820, by order of the Hon. J. C. Calhoun, Secretary of War, under the command of Maj. S. H. Long, of the U. S. Top Engineers. Early Western Travels 1748-1846. 14: 40. 1904.

of the graves a skull without teeth had been found, giving rise to another local theory that these prehistoric residents of the Meramec had jaws like a turtle. Dr. Say found that the graves were walled in and covered with flat stones. He opened several of them and saw that the bones were of ordinary size, seemingly having been buried after the flesh had been separated from them, according to the custom of certain Indian tribes. The skull of the turtle-like jaw was that of an old man who had lost his teeth.

They also devoted a great deal of time to the Indian mounds of St. Louis, locating twenty-seven along a line leading north of the city and on what they called the second bank of the river. Each of these mounds was measured with care. On the Illinois side of the river, within five miles from the river bank opposite St. Louis, they found seventy-five mounds. Their report reads as follows:

"Tumuli, and other remains of the labors of nations of Indians that inhabited this region many ages since, are remarkably numerous about St. Louis. Those tumuli immediately northward of the town, and within a short distance of it, are twenty-seven in number, of various forms and magnitudes, arranged nearly in a line from north to south. The common form is an oblong square, and they all stand on the second bank of the river."

"In the prairies of Illinois, opposite St. Louis, are numbers of large mounds. We counted seventy-five in a course of a walk of about five miles, which brought us to the hill a few years since occupied by the monks of La Trappe. This enormous mound lies nearly from north to south, but it is so overgrown with bushes and weeds, interlaced with briers and vines, that we were unable to obtain an accurate account of its dimensions."

In 1830 and 1831 George Catlin,[14] the well known In-

---

[14] Notes relative to George Catlin. Ann. Rept. Smith. Inst. 1872: 53-54. 1873.

Donaldson, Thos. The George Catlin Indian gallery in the U. S. National Museum (Smithsonian Institution) with memoir and statistics. Rept. U. S. Nat. Mus. 1885.

Matthews, Washington. The Catlin collection of Indian paintings. Ann. Rept. U. S. Nat. Mus. 1890: 593-610. 1891.

Youmans, W. J. George Catlin. Pioneers of Science in America. 336-346. 1896.

dian painter, was in St. Louis, accompanying Clark, Superintendent of Indian Affairs, on his missions to close treaties with the Winnebago, Shawnee, Sac, Fox, and Kansas Indians. In these interviews he began the series of his Indian paintings. In 1832 he painted the portraits of Black Hawk, White Cloud, and their warriors, who were prisoners of the Black Hawk War at Jefferson Barracks. In the same year he ascended the Missouri river to Fort Union, at the mouth of the Yellowstone, and returned to St. Louis in a canoe with two men, steering his frail craft the whole distance of two thousand miles with his own paddle. On this trip he visited and painted ten tribes, among them the Mandans, to whom he devoted more time and labor than to any other Indian tribe in North America.

Catlin's work was undertaken in a truly scientific spirit, and resulted in leaving to the world the fullest and most varied records in pictures and written descriptions of the aboriginal tribes as they appeared before their customs and ideas had been modified by contact with white civilization. In the preface to his catalogue he says: "Having some years since become fully convinced of the rapid decline and certain extinction of the numerous tribes of the North American Indians, and seeing also the vast importance and value which a full pictorial history of these interesting but dying people might be to future ages—I set out alone, unaided and unadvised, resolved (if my life should be spared), by the aid of my brush and my pen, to rescue from oblivion so much of their primitive looks and customs as the industry and ardent enthusiasm of one lifetime could accomplish, and set them up in a gallery unique and imperishable, for the use and benefit of future ages."

After many vicissitudes his collection was seized in London for debt, but Mr. Joseph Harrison, Jr., of Philadelphia, advanced the funds necessary to release it, and took the collection as security. It was stored until 1879, when so much of it as had escaped the ravages of time

was presented by Mr. Harrison's widow to the Smithsonian Institution, where it now is as the George Catlin Indian Gallery of the United States National Museum.

In the early part of the nineteenth century the chief object of every ambitious and thoughtful explorer was to secure for the world as complete a catalog of its plants and animals as possible. The still unknown regions of the New World, particularly those of the trans-Mississippi country with their primitive races, which had not yet been contaminated by civilization, their beasts of prey, brilliantly plumed birds and unkonwn plants, offered a splendid field for research. Even persons of royal lineage heard this call of the new world. Alexander Philip Maximilian,[15] Prince of Wied-Neu-Wied, visited North America in 1833, making a scientific exploration of the trans-Mississippi region. He was accompanied by a young Swiss artist, Charles Bodmer, who painted primitive landscapes and portraits of the aborigines.

Tarrying briefly in Boston, New York and Philadelphia, he visited the Moravians at Bethlehem and spent the winter of 1832-33 on the banks of the Wabash, in the communistic settlement of Robert Owen, where he found a good library of Americana and of natural history. Early in 1833 he made the journey to the mouth of the Ohio and up the Mississippi, arriving in St. Louis before the departure of the usual spring caravans of the western fur traders.

While in St. Louis Maximilian was invited by General Clark to accompany a deputation of Sauk and Fox Indians, headed by Keokuk, on a visit to the imprisoned chief, Black Hawk, at Jefferson Barracks. He was particularly interested in the many species of birds and butter-

---

[15] Thwaites, R. G. Travels in the interior of North America. By Maximilian, Prince of Wied. 1843. Early Western Travels 1748-1846. 22-24. 1904.

Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. 1909: 50-52.

flies he noted and the characteristic fossil crinoids of this region. He described carefully the mounds in St. Louis and crossed the river to visit those in Illinois, particularly Cahokia Mound.

Instead of joining one of the annual fur trading caravans of the Rocky Mountain Fur Company, as he had planned, Maximilian, on the advice of General Clark, took the American Fur Company's annual steamboat to their trading posts on the Missouri. At Fort Clark, the company's Mandan post, the German visitor attended various ceremonies, dances and feasts, took portraits of the chiefs, and studied the manners and customs, and myths and superstitions of this vanishing race.

About 1830 St. Louis began to feel the effects of the Oregon immigration movement, and among the earliest leaders was Nathaniel Jarvis Wyeth,[16] who conducted two expeditions to the Far West. His project was to organize a trading company to do business in the valley of the Columbia river and its tributaries, his plan being to furnish supplies to his colonists and ship his products by ocean vessels sailing to and from the Columbia. He believed that by this method he could reach the country beyond the mountains far more cheaply than by way of St. Louis.

On his second expedition Wyeth was accompanied by two scientists—Thomas Nuttall and John K. Townsend,[17]

---

[16] The correspondence and journals of Captain Nathaniel J. Wyeth, 1831-6. Sources of the History of Oregon. 1. 1899.

Young, F. C. The Oregon trail. Oregon Hist. Soc. Quart. 1: 339-370. 1900.

Drake, S. A. Nathaniel J. Wyeth. Oregon Hist. Soc. Quart. 1: 66-70. 1900.

Chittenden, H. M. The American fur trade in the far west. 1: 434-456. 1902.

Thwaites, R. G. Wyeth's Oregon, or, A short history of a long journey. Early Western Travels 1748-1846. 21: 1904.

[17] Thwaites, R. G. Narrative of a journey across the Rocky mountains to the Columbia river, and a visit to the Sandwich Islands, Chili, etc., with a scientific appendix. 1839. Early Western Travels 1748-1846. 21. 1904.

who travelled under his protection as far as the Snake river. Townsend was a well known Phliadelphia physician and naturalist, who had long been anxious to explore the far western country in the interests of science. Hearing from his friend, Nuttall, that he was preparing to join an expedition across the continent, Townsend made arrangements to accompany him, and obtained from the American Philosophical Society and the Academy of Natural Sciences of Philadelphia a commission to search for birds on their behalf.

Arriving at St. Louis on the evening of March 24, 1834, they started on their tour on the 29th. At Florissant they observed great numbers of the brown or sandhill crane (*Grus canadensis*) flying above them; some flocks were so high as to be entirely beyond their vision, although they could distinctly hear their harsh and grating cries. They had seen several flocks of the same cranes while ascending the Mississippi several days before. At St. Charles they saw quite a number of birds, among them the large pileated woodpecker (*Picus pileatus.*) On March 31st they observed large flocks of wild pigeons and thousands of golden plovers, the ground being often literally covered with them for acres. The prairie hen or pinnated grouse was also represented in large numbers. The two scientists joined Wyeth at Booneville, Mo., covering the distance from St. Louis to that point on foot.

About 1836 J. N. Nicollet,[18] a distinguished French astronomer and geographer, came to this country on a

---

[18] Report intended to illustrate a map of the hydrographical basin of the Upper Mississippi river made by J. N. Nicollet, while in the employ under the Bureau of Topographical engineers, Feb. 16. 1841. 1843.

Rogers, H. D. Jean N. Nicollet. Amer. Jour. Sci. and Arts. I. 47: 139. 1844.

Sibley, H. H. Memoir of Jean N. Nicollet. Minn. Hist. Coll. 1: 183-195. 1850-56.

Frémont, J. C. Memoirs of my life. 1: 30-72. 1887.

Winchell, N. H. Jean N. Nicollet. Amer. Geol. 8: 343-352. 1891.

scientific tour. His intention was to explore the Alleghany Mountains to the Southern States; to ascend the Red, the Arkansas and the Missouri rivers, and to examine the Mississippi river from its mouth to its source. During the five years he was engaged in these excursions he made numerous observations, calculated to serve as the foundation for an astronomical and physical geography of this country. In connection with this work he also studied the customs, habits, and languages of the several Indian nations that occupied the vast territory which he explored.

The government arranged with Nicollet to extend his survey south and west of the country which he had already explored. On this survey he was accompanied by John C. Frémont, as assistant, and Charles Geyer,[19] a St. Louis botanist.

While preparing for this expedition he was ably assisted by Dr. George Engelmann and the Jesuit Fathers of St. Louis University. He acknowledged this assistance in the following words:

"All these altitudes, with the exception of what is south of the entrance of the Ohio, have been referred to the ordinary low water in the Mississippi at St. Louis. The absolute height of the barometer at this point was not known; and my addressing myself to the reverend fathers, the Jesuits, and engaging them in making meteorological observations, was the first approach toward obtaining it. The late Rev. Mr. Van Sweevelt charged himself with the task, receiving 19 months of observations, made 5 times a day, through the years 1835 and 1836. When Mr. Van Sweevelt was obliged to discontinue his observations, I had the good fortune to find a successor, not less zealous, in Dr. Engelmann, who followed these observations with a regularity that was unlooked for from a person so occupied, otherwise with professional engagements. The years to which these observations refer are 1837, 1838, 1839, and some months of 1840. As for some time the members of the Western Academy have undertaken a regular system of meteorological observations, we have reason to

---

[19] Karl Andreas Geyer. Chronik des Gartenwesens. 3:185-187. 1853.

Reichenbach, H. G. Karl Andreas Geyer. Kew Garden Misc. 7: 181-183. 1855.

Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. 1909: 124-125.

hope that, in some years from this, there will be a definite clearing up of this point."

Nicollet was the first explorer who made much use of the barometer for obtaining the elevation of our great interior country above sea level. He was a most industrious, indefatigable, earnest, and accurate explorer, and the map which embodied the results of his labors was, in the opinion of General G. K. Warren, "one of the greatest contributions ever made to American geography."

In 1839 Dr. Adolph Wislizenus[20] of St. Louis left on a scientific tour with the annual caravan of the fur traders. Wislizenus traveled up the Kansas river to the Platte, along the Platte to Fort Laramie, over the Black Hills and the Wind River Mountains to the Green river rendezvous, and finally to Fort Hall on the Snake river. Upon his return to St. Louis he published the results of this journey under the title of "Ein Ausflug nach den Felsen-Gebirgen im Jahre 1839," an English translation of which, prepared by a son of Dr. Wislizenus, was published by the Missouri Historical Society two years ago.

In 1842 John C. Frémont,[21] through the efforts of Senator Thomas H. Benton of Missouri, was selected by

---

[20] Memoir of a tour to northern Mexico connected with Col. Doniphan's expedition, in 1846 and 1847. By A. Wislizenus, M. D. 1848.

Körner, Gustav. Das deutsche Element in den Vereinigten Staaten von Nordamerika 1818-1848. 333-337. 1880.

In memoriam Adolph Wislizenus, M. D. Trans. Acad. Sci. St. Louis. 5: xxxvii-xxxviii. 1889.

Engelmann, G. J. Frederick Adolphus Wislizenus. Trans. Acad. Sci. St. Louis. 5: 464-468. 1892.

Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. 1909: 244-246.

Wislizenus, F. A. A journey to the Rocky mountains in the year 1839. By F. A. Wislizenus, M. D. Translated from the German with a sketch of the author's life. 1912.

[21] Bigelow, John. Memoir of the life and public service of John Charles Frémont. 1856.

Upham, Charles Wentworth. Life, explorations, and public services of John Charles Frémont. 1856.

President Harrison to explore the South Pass "in aid of and auxiliary to the Oregon emigration." Leaving St. Louis, well equipped with scientific instruments and with Kit Carson as guide, Frémont examined the South Pass of the Rocky Mountains and ascended the highest peak of the Wind River Mountains, which is now called Frémont's Peak. In the course of his journey he experienced much hardship, being frequently attacked by Indians, but made many contributions to our knowledge of the Rockies, returning with a vast amount of useful observations and many hundreds of specimens in botany and geology.

In the summer of 1843 he conducted a second expedition from St. Louis up the valley of the Platte river and through the South Pass, explored the Great Salt Lake, making important discoveries in geography. From Fort Vancouver he journeyed to the Sacramento river, suffering severely from hunger and cold. Returning through the Great Basin and the South Pass, he finally reached St. Louis again late in 1844.

In the spring of 1845 Frémont set out on his third expedition to explore that section of the Rocky Mountains which gives rise to the Arkansas, the Rio Grande del Norte of the Gulf of Mexico, and the Rio Colorado of the Gulf of California; to complete the examination of the Great Salt Lake and its interesting region; and to extend the survey west and southwest to the Cascade and Sierra Nevada Mountains.

Frémont undertook a fourth expedition in 1848, at his own expense, assisted by public spirited citizens of St. Louis, to explore a route for a railway from St. Louis to California. He left St. Louis October 9, 1848, proceeding by way of the Kansas river to the head-waters

---

Frémont, J. C. Memoirs of my life. 1887.
Greely, A. W. John Charles Frémont, the Pathfinder. Men of Achievement. Explorers and Travellers. 212-239. 1893.
Dellenbaugh, F. S. Frémont and '49. 1914.
Sabin, E. L. Kit Carson days. (1809-1868.) 1914.

of the Colorado and across the Wahsatch Mountains into California.

In the spring of 1843 John James Audubon,[22] the ornithologist, spent several weeks in St. Louis, preparing for a trip up the Missouri in the steamboat of the American Fur Company. While here he was entertained by the members of the Western Academy of Natural Sciences, being elected an honorary member of that organization April 17, 1843.

In 1846 Wislizenus again left St. Louis, this time with the intention of making a tour through northern Mexico and Upper California. His principal object was to study the topography and natural history of that country. He made a large collection of rare and theretofore unknown plants, examined the geological formation of the rocks, visited many mines, and analyzed some of the ores. He made barometrical observations to ascertain the elevation above the sea level, compiled meteorological tables, and gathered data relating to the number, industry, manners, customs, and previous history of the inhabitants of the country through which he passed.

Shortly after he had started on this expedition, which he had outfitted from his private means, the war with Mexico broke out, and interfered with his plans. He was detained many months as he states "in a very passive situation" by the Governor of the State of Chihuahua. After the arrival of American troops he joined the medical department of the Army and returned to the United States by way of Monterey.

Although the results of his researches must have been very unsatisfactory to him, Wislizenus had the satisfaction of having been one of the first scientific pioneers

---

[22] St. John, H. R. Audubon. 1856.
Pierce, B. K. Audubon's adventures. 1890.
Youmans, W. J. John James Audubon. Pioneers of Science in America. 152-166. 1896.
Audubon, M. R. Audubon and his journals. 1897.
Burroughs, John. John James Audubon. 1902.

who explored a great part of northern Mexico and the southwestern United States. At the instance of Senator Benton, the United States Senate ordered printed five thousand copies of his journal, together with the accompanying tables and maps. Dr. Engelmann worked up the flora from the specimens collected by Dr. Wislizenus on this trip.

From 1844 to 1860 more than twenty expeditions were sent out by the government with the object of determining the best route for a railroad to the Pacific coast. The information obtained through these expeditions was published by the government in a large series of maps and reports.[23] For the later expeditions under King, Wheeler, Powell, Hayden, and others, gotten up for the purpose of studying the topography, geology, and natural history of the country, St. Louis was no longer the point of departure and return, on account of the advent of railroads west of the Mississippi river.

From the earliest days the history of science in St. Louis has been more or less intimately connected with the institutions for higher education in the city. The oldest institution of this character is the St. Louis University,[24] founded in 1818, three years before Missouri was admitted to statehood, when the Right Reverend Louis William Du Bourg, Bishop of Louisiana, opened the St. Louis Academy, which grew into the St. Louis College, and finally developed into the St. Louis University. The university charter was granted by a special act of the legislature in 1832. St. Louis University is

---

[23] Warren, G. K. Memoir to accompany the map of the territory of the United States from the Mississippi river to the Pacific Ocean, giving a brief account of the exploring expeditions since A. D. 1800. Reports of explorations and surveys, to ascertain the most practicable and economical route for a railroad from the Mississippi river to the Pacific Ocean. 11. 1859.

[24] Hill, W. H. Historical sketch of the St. Louis University. 1879.
Fanning, W. H. W. Historical sketch of the St. Louis University. Bull. St. Louis Univ. 4: 4. 1908.

probably the oldest university west of the Mississippi river, and certainly the oldest in the Louisiana Purchase Territory.

Among the early professors was Father De Smet, who became so illustrious in succeeding years as a missionary among the Indians of the Rocky Mountains. A copy of Father De Smet's map of the Columbia river and the Puget Sound region is among the historical treasures of the university. The original map was presented to President Polk by Father De Smet during the international controversy with the British Government about the northwestern boundary. This map was of great importance as evidence in the settlement of this vexatious question.

In 1836 the closing of a college in France gave St. Louis University the opportunity to purchase quite an assortment of chemical and physical apparatus of great value. This gave the university a high scientific rank, which it has maintained to the present time. In 1854 an observatory was added, where some of the best work of the Fathers has been done. Since 1889 the university has maintained a post-graduate School of Philosophy and Science, and in 1908 added a School of Advanced Science, the object of which is to train scientific specialists.

As early as 1835 the President of the University held a consultation with the Medical Society of St. Louis relative to the establishment of a medical faculty at the university. Dr. William Beaumont,[25] famous for his observations on the process of digestion, was a member of the first medical faculty of the university. This department does not seem to have made much progress up to the year 1842, when it was reorganized, but was very successful from that time on, especially after the accession to the

---

[25] Reyburn, Thos. Memoir of the late Dr. Beaumont. St. Louis Med. Surg. Jour. 12: 127-139. 1854.

Osler, Wm. William Beaumont. A pioneer American physiologist. Jour. Amer. Med. Assoc. Nov. 1902.

Myer, J. S. Life and letters of Dr. William Beaumont. 1912.

faculty of Dr. Charles Alexander Pope[26] in the year 1843, who was later on dean of the faculty. Dr. Pope enjoyed such popularity among the people that the medical school was usually referred to as "Pope's College." Through his influence his father-in-law, Col. John O'Fallon, erected a new building for the medical college in 1850, at Seventh and Myrtle streets, the latter now Clark avenue. On the faculty were also Dr. Daniel Brainard, a distinguished author and one of the most prominent surgeons of the northwest; Dr. Moses L. Linton,[27] founder of the "St. Louis Medical and Surgical Journal"; Dr. Wm. McPheeters,[28] Dr. Linton's associate; and Dr. Hiram A. Prout.[29]

It is one of the glories of the old medical faculty of St. Louis University that the "St. Louis Medical and Surgical Journal" was founded and edited by its professors. The "St. Louis Medical and Surgical Journal"

---

[26] Biographical sketch of Prof. Charles A. Pope. St. Louis Med. Surg. Jour. II. 3: 1-6. 1866.

Death of Professor Charles A. Pope. St. Louis Med. Surg. Jour. II. 7: 384. 1870.

Chesney, J. P. Charles A. Pope. Trans. Amer. Med. Assoc. 29: 741-747. 1878.

Outten, W. B. Characterization of Charles A. Pope. Tri-State Med. Jour. 3: 46. 1896.

Goodwin, E. J. A history of medicine in Missouri. 38-39. 1905.

Outten, W. B. Dr. Charles Alexander Pope. Glimpses of early St. Louis medical history. Medical Fortnightly 33-34: 253-256. 1908.

[27] Biographical sketch of Prof. M. L. Linton. St. Louis Med. Surg. Jour. II. 4: 1-8. 1867.

Death of M. L. Linton. St. Louis Med. Surg. Jour. II. 9: 383-387. 1872.

Chesney, J. P. M. L. Linton. Trans. Amer. Med. Assoc. 29: 697-701. 1878.

Sawyer, A. L. M. L. Linton. St. Louis Med. Surg. Jour. 64: 52-57. 1893.

Outten, W. B. Dr. M. L. Linton. Glimpses of early St. Louis medical history. Medical Fortnightly. 33-34: 173-174. 1908.

[28] W. M. McPheeters. St. Louis Med. Surg. Jour. 64: 112-116. 1893.

W. M. McPheeters. Med. Rec. New York. 67: 463. 1905.

Goodwin, E. J. A history of medicine in Missouri. 234-236. 1905.

[29] Holmes, N. L. Hiram A. Prout. Trans. Acad. Sci. St. Louis. 2: 178-179. 1862.

was one of the first prominent medical publications, not only in the Mississippi Valley, but in America. A short time after this Journal had made its appearance, a Boston weekly devoted to medical science ceased publication, and for many years the St. Louis paper stood alone in the vast region west of the Alleghany Mountains as the sole exponent of medical science. From the outset it was conducted with signal ability, and as an ally in the progress of civilization in the Mississippi region its services cannot be measured.

The connection between the University and the Medical College was not destined to be permanent. When the "Know Nothing" excitement arose and began to spread over the land, in 1854 and 1855, it was decided by a majority of the medical faculty that it was expedient for the medical department, under the circumstances, to be separated from the University, and henceforth conducted under a distinct charter. By mutual consent, its connection with St. Louis University closed in 1855.

The school was incorporated under the name of the St. Louis Medical College[30] and continued as an independent school until 1891, when an offer of alliance with Washington University was accepted, and the school became the Medical Department of Washington University. In 1899 the Missouri Medical College was included, the united colleges continuing as the Medical Department of Washington University.

In 1901 the Marion-Sims College of Medicine was consolidated with the Beaumont Hospital Medical College, and in 1903 this Marion-Sims-Beaumont College of Medicine became the Medical Department of the St. Louis University.

In 1836 Kemper College[31] was incorporated with a uni-

---

[30] Baumgarten, Gustav. The St. Louis Medical College. 1892.
Grindon, Jos. History of the St. Louis Medical College. 1898.
Goodwin, E. J. A history of medicine in Missouri. 131-133. 1905.

[31] White, Greenough. An apostle of the western Church. Memoir of the right reverend Jackson Kemper. 1900.

versity charter under the auspices of the Protestant Episcopal Church. This institution was located about four miles southwest of St. Louis, on a tract of land of 125 acres, adjacent to the old county farm of St. Louis County, and near the site of the present Insane Asylum. The college opened in October, 1838. In 1840 Dr. Joseph Nash McDowell organized a medical department, the first course of lectures being given in 1840-41 in a building erected on a high bank of Chouteau's Pond, at the corner of Ninth and Cerre streets, where some of the buildings of the Wainwright Brewery now stand.

Although Kemper College never attained the position among western colleges which its promoters had hoped it would, it was, nevertheless, a popular academic school for some years, but in 1845 was discontinued on account of lack of financial aid. The County Court of St. Louis County purchased the college buildings and used them as an asylum for the poor, known as the Poor House. When Kemper College failed, its medical department became the Medical Department of the State University, and was so conducted until the general reorganization of the State University, when a separate charter was procured under which the college was independently conducted as the Medical Department of the Missouri Institute of Science, more commonly known, however, as the Missouri Medical College,[32] or McDowell's College. The college was located on the corner of Eighth and Gratiot streets. At the beginning of the Civil War it was confiscated by the United States government and became a famous military prison, known as the Gratiot Street Prison. After the close of the war

---

[32] Valentine, Mary T. (Mary Young Ridenbaugh.) The biography of Ephraim McDowell, M. D. 2nd ed. rev. 158-180. 1894.

Goodwin, E. J. A history of medicine in Missouri. 129-131. 1905.

Outten, W. B. Dr. Joseph Nash McDowell. Glimpses of early St. Louis medical history. Med. Fortnightly. **33-34**: 143-146. 1908.

Barbee, A. B. History of the Missouri Medical College from 1840 to 1861. Jour. Mo. Med. Assoc. July, 1914.

the faculty was reorganized and lectures were resumed in the same building. After a career of fifty-nine years the Missouri Medical College in 1899, in conjunction with the St. Louis Medical College, became the Medical Department of Washington University.

In May, 1845, the faculty of the Medical Department of Kemper College started a journal called the "Missouri Medical and Surgical Journal," but in September, 1848, it was merged with the "St. Louis Medical and Surgical Journal."

Edward Wyman, who established an English and Classical High School in St. Louis in 1843, set about to form a museum of natural history under the direction of Mr. J. P. Bates. In his "Thoughts About St. Louis" Hogan says:

"For several years past Mr. Wyman has been collecting specimens of 'Natural History,' and has had engaged in their preparation and arrangement a gentleman of unquestionable skill, of which his work is a most conclusive demonstration. Mr. Bates, the naturalist employed in this department, works steadily, quietly, yet with all the enthusiasm of a true devotee to the science of his choice, in the tasteful preparation and arrangement of this beautiful cabinet. No pains, or expense, or labor is spared, either in the collection or preparation of these specimens. There are specimens from almost all lands, while river, lake and ocean furnish a few. Mr. Bates has just returned from Europe whither he went to collect rare specimens, and returned laden with spoils. The collections, especially in the department of ornithology, are as fine as I have ever seen anywhere—probably finer than can be found in this country, not so much for the great number of specimens—for it is very select—but for their beauty, their rarity, and the tasteful manner of their preparation and display. Indeed, there are many specimens, both in this and other branches, which I have not seen in other cabinets and museums in the United States, and I doubt if they can be found in private or public cabinets in this country. This whole Museum now embraces some two thousand and five hundred specimens, and there are many very choice ones brought by Mr. Bates from Europe in his last visit, not yet put up."

This museum, which was on the third floor of Wyman's Hall, on Market street, opposite the Court House, was purchased in 1851 by Dr. Albert C. Koch and conducted for some years as the St. Louis Museum or Koch's Museum.

In 1853 Wayman Crow secured from the Legislature of Missouri a charter for an educational institution in St. Louis to be called the Eliot Seminary. The gentlemen named in this charter met and organized, and chose William G. Eliot, President, in 1854. In deference to the wishes of President Eliot the name of the institution was changed to the Washington Institute, and in 1857, when the charter was amended, to Washington University.[33] The university was formally inaugurated in 1857—in President Eliot's words, "An institution for the public benefit."

Washington University has always been in close touch with the Academy of Science of St. Louis. From its faculty have come some of the most active workers and officers of the Academy. To the Transactions they have contributed many and important papers. At a time when the Academy had no other home the doors of the university were opened to it for its meetings and the housing of its library and collections.

In 1857 Henry Shaw,[34] a wealthy retired merchant of St. Louis, who had a large garden connected with his country home, commissioned Dr. Engelmann, then in Europe, to examine botanical gardens and make such suggestions as he might deem of value in establishing a botanical garden. The Missouri Botanical Garden[35] is the offspring of Dr. Engelmann's researches in that line.

---

[33] Twenty-fifth anniversary. 1882.

Chaplin, W. S. Higher education in St. Louis and Washington University. 1893.

Snow, M. S. Higher education in Missouri. 129-163. 1898.

Eliot, C. C. William Greenleaf Eliot, minister, educator, philanthropist. 1904.

Washington University 1857-1907. 1907.

[34] Dimmock, Thos. Report Mo. Bot. Garden. 1: 7-25. 1890.

[35] Trelease, Wm. The Missouri Botanical Garden. Rept. Mo. Bot. Gard. 1. 1890.

Trelease, Wm. The Missouri Botanical Garden. Pop. Sci. Month. 62: 193-221. 1903.

Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. 1909: 246-250.

In 1859 Mr. Shaw secured the passage of an act of the Legislature of Missouri which empowered him to deed or will to trustees such of his property as he wished to set aside for the following purposes, namely: "to maintain and establish a botanic garden for the cultivation and propagation of plants, flowers, fruit and forest trees, and for the dissemination of the knowledge thereof among men, by having a collection thereof easily accessible; by the establishment of a museum and library in connection therewith, as also by establishment of public lectures and instruction upon botany and its allied sciences, when it shall be deemed advisable in furtherance of the general objects of said trust; and for the purpose of maintaining a perpetual fund for the support and maintenance of said garden, its care and increase, and the museum, library and instruction connected therewith."

After Mr. Shaw's death the Missouri Botanical Garden was organized in accordance with the terms of his will. At the Garden will be found one of the best botanical libraries in America, and among a vast herbarium of plants representative of every corner of the earth will be seen the Engelmann collection, containing many rare specimens of important types of plants collected by some of the early western explorers.

In 1885 Mr. Shaw proposed to the directors of Washington University to endow in that institution a school of botany with the understanding that by testamentary provision the best use of his garden for scientific study and investigation should be insured to its professors and students. The offer was accepted and the Henry Shaw School of Botany formally inaugurated.

Among those who came to America in 1848 because of dissatisfaction with the established government of Baden, Germany, was Dr. Adam Hammer,[36] who arrived

---

[36] Dr. Adam Hammer. St. Louis Med. Surg. Jour. **35**: 314-316. 1878. Goodwin, E. J. Humboldt Medical College. A history of medicine in Missouri. 136. 1905.

in St. Louis with his faithful friend, Hecker, on October 28, 1848. Dr. Hammer soon became convinced of the need of reform in American medical education, and, in 1855, obtained from the Legislature of Missouri a charter for an institution to carry out his ideas. The St. Louis College of Medical and Natural Sciences was founded for the specific purpose of placing American medical education upon a plane similar to that of the best foreign universities. It was the first medical school in the United States to require high preliminary qualifications for matriculation, a graded course of instruction, and four courses of lectures. In those days the time allotted to the study of medicine was two courses of four months each, the same lectures being given in the second course that had been delivered in the first. All branches of medical science were taught in four months, the student getting the alpha and omega of the science in one term. Dr. Hammer insisted on four courses of lectures in a graded course of instruction. This institution was compelled to close its doors in 1856.

In the fall of 1859 Dr. Hammer opened the "Humboldt Institut, oder Deutsche Naturwissenschaftlich-Medicinische Schule in St. Louis." This college was unique in the annals of American medicine in that instruction was given in the German language. During the early part of the Civil War the college was closed, but was reopened later on and lectures were given until 1866, when the name was changed to the Humboldt Medical College, which ceased to exist in 1869 because of a split in the faculty.

At the inauguration of the Henry Shaw School of Botany of Washington University in 1885, Chancellor Eliot in the course of his address said:

Outten, W. B. Dr. Adam Hammer. Glimpses of early St. Louis medical history. Med. Fortnightly **33-34**. 171-173. 1908.

Ball, J. M. Dr. Adam Hammer, surgeon and apostle of higher medical education. Jour. Mo. State Med. Assoc. **6**: 3. 1909.

"More than forty years ago, five or six young men, of whom I was one, met together, on Main street, near Chestnut, in the office of the Honorable Judge, Mary P. Leduc. The object was to found an Academy of Science, but not one of our number really knew enough of science to found a primary school, except Dr. George Engelmann, who was an enthusiastic student, especially in botanical research, and who inspired us all with something of his zeal. We organized a society and proceeded to purchase five or six acres of ground, far out of the city, I think near Eighth street and Chouteau avenue. There Dr. Engelmann began a botanical garden and aboretum on a small scale. It was kept up, after a fashion, for some years, but the society faded out and the land was sold, and apparently there was an end of the academy. But under the law of the survival of the fittest, Dr. Engelmann 'survived' and became an academy of science in himself."

This was the Western Academy of Natural Sciences.[37] The foundation for this first edifice of science in the Mississippi Valley and probably the first west of the Alleghany Mountains was laid in 1837, when a charter was granted to H. King, George Engelmann, B. B. Brown, P. A. Pulte, William Weber, Theodore Engelmann and G. Schuetze, as incorporators. The main promoters of this new society were Dr. Engelmann and Dr. Wislizenus, both destined to play important rôles in the future Academy of Science.

Through the efforts of these men the lamp of science was kept burning for some years, at a time when St. Louis was nothing more than a small frontier town. An address, together with the Act of Incorporation, Constitution and By-Laws, were respectfully submitted to the "friends of knowledge," soliciting funds, new members, and contributions to the proposed museum and library.

---

[37] Act of incorporation, constitution and by-laws of the Western Academy of Natural Sciences at St. Louis. 1837.

The address stated that St. Louis was most fortunately situated for work in natural science, being on the edge of that "immense tract of country that lies between the western borders of civilization and the Pacific ocean," upon which "the attention of the scientific world is every day becoming more strongly fixed," because of its geological peculiarities, its immense mineral resources and its abundant fauna and flora.

A museum had been started, an effort made to establish a botanical garden, and a library of about one hundred volumes gathered, when, through lack of support, the Western Academy of Natural Sciences ceased to exist. Just how many years the Academy was active is not known. On April 17, 1843, however, the society elected to honorary membership John James Audubon. The diploma was signed by George Engelmann, President; B. B. Brown, Vice-President; Wm. R. Singleton, Corresponding Secretary; and L. M. Sell, Recording Secretary.

For a score or more years informal metings of the local scientists were no doubt held and the slumbering Academy discussed. Finally the opportune moment for relighting the lamp of science seems to have arrived, when, according to previous agreement, Drs. Engelmann, Prout, Wislizenus, Pope, Pallen, Tingley, Stevens, McPheeters, and Shumard, and Messrs. Charles P. Chouteau and James B. Eads assembled on the eighth of February, 1856, to form in St. Louis a society for the cultivation of various branches of science. Dr. Engelmann was called to the chair, and Dr. Shumard appointed Secretary. Dr. Pallen stated that the acknowledged want of an institution in the west for the cultivation of various branches of science had caused a desire in the minds of those present to found one in this city. Its object should be especially the investigation of subjects pertaining to the various branches of science, the accumulation of a scientific library, and the formation of a museum, which should contain collections in the various departments

embraced in the term, Science, and also objects illustrating the manners and customs of the aborigines of North America. Dr. Engelmann remarked that to establish firmly such a society it would be necessary to collect a certain amount of money. It was also deemed advisable to secure for the society certain valuable collections of fossil remains and other natural objects now in the city. Drs. Tingley and Shumard and Mr. Chouteau were asked to prepare a circular to be addressed to such persons as might be favorable to the objects in view.

At the last preliminary meeting a Constitution and By-Laws were adopted, and an election held, which resulted in the choice of the following gentlemen as officers:

President .....George Englemann.
First Vice President.....Hiram A. Prout.
Second Vice President.....Nathaniel Holmes.
Secretaries .....Benjamin F. Shumard,
Wm. H. Tingley.
Treasurer .....James B. Eads.
Curators .....Moses M. Pallen, Adolph Wislizenus, Charles W. Stevens,
Benjamin F. Shumard.
Board of Council.....George Engelmann, H. A. Prout,
Nathaniel Holmes, B. F. Shumard,
Chas. A. Pope, Wm. H. Tingley,
Chas. P. Chouteau.

After several preliminary meetings respecting the organization of the Society, a meeting was held on the tenth of March, 1856, in the Hall of the Board of Public Schools, at which were present the following fifteen founders of the present Academy of Science:[38] George Engelmann, Hiram A. Prout, Moses M. Pallen,[39] Benja-

---

[38] Starr, Frederick. The Academy of Science of St. Louis. Pop. Sci. Month. Mar., 1898.

Trelease, Wm. The Academy of Science of St. Louis. A biography. Pop. Sci. Month. Dec., 1903.

Celebration of the fiftieth anniversary of the first meeting. Trans. Acad. Sci. St. Louis. 16: i-xcix. 1906.

[39] Moses M. Pallen. Trans. Acad. Sci. St. Louis. 3: ccxxii. 1876.
Moses M. Pallen. Trans. Amer. Med. Assoc. 28: 620. 1877.
Moses M. Pallen. St. Louis Cour. Med. 30: 383. 1904.

min F. Shumard, Charles A. Pope, William H. Tingley, James B. Eads, William M. McPheeters, Simon Pollak,[40] Charles W. Stevens,[41] Adolph Wislizenus, Nathaniel Holmes,[42] M. L. Linton, J. H. Watters,[43] and Charles P. Chouteau.

Dr. Engelmann[44] came to America in 1832 and settled in St. Louis in 1834. For fifty years his explorations and investigations made the city respected as the home

---

Outten, W. B. Dr. M. M. Pallen. Glimpses of early St. Louis medical history. Med. Fortnightly. **33-34.** 146-148. 1908.

[40] Simon Pollak. St. Louis Med. Rev. **48**: 397-403. 1903.
Alt, Adolf. Simon Pollak. Amer. Jour. Ophth. **20**: 350. 1903.
Lutz, F. J. The autobiography and reminiscences of S. Pollak. 1904.
Goodwin, E. J. A history of medicine in Missouri. 39-41. 1905.

[41] Charles W. Stevens. St. Louis Med. Surg. Jour. **58**: 196. 1890.
Goodwin, E. J. A history of medicine in Missouri. 39. 1905.
Outten, W. B. Dr. Chas. W. Stevens. Glimpses of early St. Louis medical history. Med. Fortnightly **33-34**: 310-313. 1908.

[42] Nathaniel Holmes. Trans. Acad. Sci. St. Louis. 11: xxvii-xxviii. 1901.

[43] John Henry Watters. St. Louis Cour. Med. **30**: 382. 1904.

[44] Körner, Gustav. Das deutsche Element in den Vereinigten Staaten von Nordamerika 1818-1848. 327-331. 1880.
Gray, Asa. Memorial of George Engelmann. Amer. Jour. Sci. III. **28**: 61-67. 1884.
Gray, Asa. George Engelmann. Proc. Amer. Acad. Arts and Sci. **19**: 516-522. 1884.
Gray, M. L. George Engelmann. Trans. Acad. Sci. St. Louis. **4**: xc-xcv. 1884.
Sargent, C. S. George Englemann. Science. **3**: 405-408. 1884.
Sander, Enno. George Engelmann. Biography. Trans. Acad. Sci. St. Louis. **4**: 1-18. 1886.
Sketch of George Engelmann, M. D. Pop. Sci. Month. **29**: 260-265. 1886.
Trelease, Wm. and Gray, Asa. The botanical works of the late George Engelmann collected for Henry Shaw, Esq. Edited by. 1887.
Boisliniere, L. C. Biographical notice of George Engelmann. St. Louis Med. Surg. Jour. **65**: 364-368. 1893.
White, C. A. Memoir of George Engelmann. 1809-1884. Biog. Mem. Nat. Acad. Sci. **4**: 1-21. 1902.
George Engelmann. 1809-1909. Trans. Acad. Sci. St. Louis. **18**: xlvii-l. 1909.
Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. **1909**: 125-129.
White, C. A. George Engelmann. A history of the first half-century of the National Academy of Sciences 1863-1913. 129-132. 1913.

of science among men of learning at home and abroad. His early stay in America he spent in study in and around St. Louis, carrying his investigations to southern Illinois, southern Missouri, and into Arkansas. The reports which Dr. Engelmann made upon the resources of the Mississippi Valley in the vicinity of St. Louis were the principal features of a periodical called "Das Westland," published in Heidelberg in the interests of German emigration to the Mississippi Valley.

Dr. Engelmann was not only one of the leading medical practitioners, but one of the foremost botanists of his day. During many years of an active, useful life he found sufficient time, in the leisure hours of his practice, to devote to a series of most valuable scientific investigations. In addition to his professional and botanical labors, he was a zealous meteorologist. On establishing his home in St. Louis, he began a series of thermometrical and barometrical observations, which he continued regularly and systematically for nearly fifty years—anticipating by a full third of a century the local observations of the United States Weather Bureau. After his death the Academy published his observations covering a period of forty-seven years.

In 1859 Dr. Engelmann published a paper concerning the elevation of St. Louis above sea level. This was an important paper for the reason that St. Louis was then the point upon which were based the computations for determining the altitudes of such places in the Far West as were visited by the early exploring expeditions of Nicollet, Frémont, Emory, and others. Dr. Engelmann, after a series of barometric observations in 1853, determined a directrix of 404.9 feet for the city of St. Louis—a figure which differed by only 7.8 feet from the 412.7 feet mark as determined later on by exact leveling of government departments, and by only 2.2 feet from the original 410.5 of Nicollet, which was made in 1841 by barometric determinations based upon data furnished in part by Dr. Engelmann himself.

On coming to the Mississippi Valley, Dr. Engelmann found himself surrounded by plants, most of which were unknown to him. He studied them systematically in their relations to each other, devoting himself to a particular genus or group of plants until he had thoroughly mastered it. Among his many investigations of plants was that of the Cactus family, upon which his work was most extensive and important. His treatise on this family is still quoted as the highest authority. This stupendous task was begun in his sketch of the botany of the expedition of Dr. Wislizenus to northern Mexico and was concluded with two illustrated memoirs, one contributed to the fourth volume of the Pacific Railroad Expedition Reports, and the other to Emory's Report on the Mexican Boundary Survey. His splendid work on the two peculiarly American groups of plants, the Yucca and Agave, was published in the third volume of the Transactions of the Academy of Science. His various papers on the American oaks and 'conifers, published in the Transactions of the Academy and elsewhere, are of the highest interest to science. Nearly all that we know scientifically of our species and forms of grapes is directly due to Dr. Englemann's investigations. Much of his work on the grape vines of Missouri was published by the Academy of Science.

In the year following his death the principal professorship in the Henry Shaw School of Botany, which was then established, was named after him. His friend and co-worker, Dr. C. C. Parry, named for him a peak in the Rocky Mountains and also the picturesque cañon through which now passes the cog wheel railroad from Manitou to the summit of Pike's Peak. The name Engelmann has become unalterably associated with the Buffalo grass of the plains, with the noblest Conifers of the Rocky Mountains, and with the most stately Cactus in the world, verifying the prediction of his biographer that "the Western plains will still be bright with the yellow rays of *Engelmannia*, and that splendid Spruce, the fairest of them all,

which bears the name of Engelmann, will still, it is to be hoped, cover with noble forests the highest slopes of the Rocky Mountains, recalling to men, as long as the study of trees occupies their thoughts, the memory of a pure, upright, and laborious life."

Associated with Dr. Engelmann in the earlier years of his career in St. Louis was Dr. Adolphus Wislizenus, whose name will ever be honorably associated with the history of science in St. Louis. Although Dr. Wislizenus had settled in St. Louis to practice medicine, scientific exploration lured him on two extensive expeditions—one in 1839 to the Rocky Mountains and the other in 1845 to northern Mexico. The results of his Mexican tour will be regarded as his most valuable contribution to science, having been publicly acknowledged by Humboldt as of value to him in his studies of that region.

Among some of the many other distinguished members of the Academy of Science, whose memories we honor and cherish and to whom we are indebted for liberal contributions to knowledge—often acquired under the most trying circumstances—are Hiram A. Prout, to whom is justly due the credit of having first called attention to the existence of the gigantic extinct remains in the Bad Lands of Nebraska by his excellent memoir on Palaeotheroid and other bones, and for whom the *Titanotherium Proutii* will stand as a lasting monument in the world of science; James B. Eads,[45] who devised and furnished our Government with its first and most useful armored steamboats, who constructed the bridge spanning the Mississippi at St. Louis which bears his name, and who by means of jetties at the mouth of the Mississippi opened

---

[45] James B. Eads. Trans. Acad. Sci. St. Louis. 5: xiii-xv. 1887.
James B. Eads. Sci. Amer. Supp. Apr. 9, May 7, 1887.
Corttell, E. L. James B. Eads. Jour. Assoc. Eng. Soc. 9: 456-461. 1890.
Sellers, Wm. Memoir of James Buchanan Eads. 1820-1887. Biog. Mem. Nat. Acad. Sci. 3: 59-80. 1895.
How, Louis. James B. Eads. 1900.

an unobstructed pathway or channel from the Mississippi to the Gulf of Mexico; Charles V. Riley,[46] the investigator of the ravages and life history of the Rocky Mountain Locust and the organizer and first head of the United States Bureau of Entomology, the man who saved the grape industry of Europe from the ravages of the American Phylloxera by grafting the susceptible European varieties upon roots of the more resistant American species; Benjamin F. Shumard,[47] of the Missouri State Geological Survey, and later State Geologist of Texas; George Clinton Swallow, who conducted the geological survey of this state from 1853 to 1860 and made known the vast coal beds of Missouri; Theodore C. Hilgard,[48] whose work on phyllotaxis and kindred subjects is well known, and Abram Litton,[49] the first thoroughly trained chemist west of the Mississippi.

The act of incorporation declares the object of the Academy to be the advancement of science and the estab-

---

[46] Nipher, F. E. Charles V. Riley. Trans. Acad. Sci. St. Louis. 7: xlvi-xlvii. 1895.

Packard, A. S. Charles Valentine Riley. Science. II. 2: 745-751. 1895.

Goode, G. B. A memorial appreciation of Charles Valentine Riley. Science. II. 3: 217-225. 1896.

Howard, L. O. Charles Valentine Riley. Proc. Soc. Pro. Agric. Sci. 17: 108-112. 1896.

Howard, L. O. Charles Valentine Riley. Bull. Phil. Soc. Washington. 13: 412-416. 1900.

Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. 1909: 251-252.

[47] Benjamin F. Shumard. Trans. Acad. Sci. St. Louis. 3: xvii 1869.
Benjamin F. Shumard. Amer. Jour. Sci. II. 48: 294-296. 1869.
Benjamin F. Shumard. St. Louis Med. Surg. Jour. II. 6: 286. 1869.
Yandell, L. P. A biographical sketch of Benjamin Franklin Shumard. Western Jour. Med. 4: 738-749. 1869.

[48] Theo. C. Hilgard. Trans. Acad. Sci. St. Louis. 3: clxxvi. 1875.
Spaulding, Perley. A biographical history of botany at St. Louis, Missouri. Pop. Sci. Month. 1909: 130-133.

[49] Broadhead, G. C. Abram Litton, M. D. Acad. Sci. St. Louis. 12: xxiv-xxvii. 1902.
Abram Litton. St. Louis Cour. Med. 30: 312-313. 1904.

lishment in St. Louis of a museum and library for the illustration and study of its various branches.

At the second meeting of the Academy, April 21, 1856, the generous offer of Dr. Charles A. Pope for the free use of the Cabinet Hall and other rooms in the Dispensary Building of the St. Louis Medical College, was thankfully accepted. In Pope's College were established the first museum and library of the Academy.

At a special meeting called by the President, August 4, 1856, the library, belonging to the Western Academy of Natural Sciences, consisting of 120 volumes, the mineralogical and geological collection, cases and apparatus, were donated to the Academy.

During the first year of its existence the progress of the Museum had been so encouraging that standing committees were appointed in the following subjects:—Ethnology, Comparative Anatomy, Mammalogy, Ornithology, Herpetology and Ichthyology, Chemical Geology and Malacology, Entomology, Botany, Palaeontology and Geology, Mineralogy, Chemistry, Physics, Embryology and Monstrosities. At the end of the second year Astronomy and Meteorology were added.

Prominent among the donors appears, again and again, the name of Mr. Charles P. Chouteau,[50] who was ever mindful of the Academy's needs when on his expeditions into the Far West in the interests of the fur trade. At one of the meetings he requested the Academy "to name some naturalist to accompany him on his expedition to the Upper Missouri free of expense to the society." At another time we find recorded in the minutes that "numerous mounted and preserved specimens of mammals, birds, reptiles and fishes, collected on the Upper Missouri river by the taxidermist sent by the Academy to accompany Mr. Charles P. Chouteau, on the annual trip of the American Fur Company's boats, were received

---

[50] In memoriam Charles Pierre Chouteau. Trans. Acad. Sci. St. Louis. 11: xxi-xxii. 1901.

and deposited in the Museum.'' Of the many and priceless gifts of Mr. Chouteau only a section of the Fort Pierre meteorite now remains, the balance having been destroyed in the fire of 1869.

Even the gloomy days of the Civil War added to the Academy's museum. The Western Sanitary Commission deposited with the Academy what remained of the natural history collection of McDowell College, which had been confiscated and turned into a federal prison.

At the close of the war the Academy regained some of its accustomed activity, and, in the Fall of 1868, a committee was appointed to secure rooms in the Polytechnic Building, as the museum and library had far outgrown the quarters in Pope's College. While negotiations were still pending, fire broke out in May, 1869, destroying almost the entire museum. Fortunately the library was saved. The loss of the Academy museum was irreparable and no efforts were made to re-establish it until a few years ago.

The palaeontological collections were perhaps the most valuable part of the museum. They contained a large number of teeth and bones of *Mastodon giganteus* and *Elephas primigenius*, in good preservation, from Missouri and other western states; a full skeleton of the great cave bear from Europe; a fine example of the head of *Bos bombifrons*, an extinct fossil ox exhumed from Chouteau's Pond. This fossil is so rare that only two specimens had been discovered previously. The Academy's specimen withstood the fire and is in its present museum. Through the liberality of Mr. Charles P. Chouteau the Academy had obtained an extensive and beautiful collection of fossils, collected by F. V. Hayden in the Bad Lands of Nebraska, which had later been increased by the purchase of the one-fourth interest owned by Colonel A. J. Vaughan. This gave to the Academy an equal share with the Academy of Natural Sciences of Philadelphia in the splendid collection made by the United States Geological Survey of the Territories from

the Bad Lands and other portions of the Upper Missouri country. In this collection were fourteen specimens of extinct fossil turtles, the remains of the gigantic Titanotherium, two species of extinct rhinoceros, a hyena, and two species of Oreodon. In the geological department were also rocks, mineral and ores collected by Dr. Wislizenus during his exploration of northern Mexico; cretaceous and tertiary fossils obtained by Dr. Koch while Zeuglodon hunting in Mississippi and Arkansas; fossils from the carboniferous and cretaceous formations of Texas and New Mexico; a series of rocks and fossils collected by the expedition of Lieutenant Bryan on his survey of a wagon route from Kansas to Utah in 1860-61; and type specimens of fossils from the Upper Missouri, collected by Lieutenant G. K. Warren.

In the mineralogical department were over twelve hundred specimens of minerals from various parts of the United States and a collection of meteorites, among them the Fort Pierre meteorite, found about twenty miles from Fort Pierre and brought to St. Louis by the American Fur Company in 1857. When found it weighed thirty-five pounds. A section of this meteorite is still in the Academy museum.

In the museum of the Academy were also housed choice suites of reptiles, skulls and skins of mammals from the Platte River country and other portions of the Rocky Mountains; bird skins collected by Captain John Pope in California, Texas and New Mexico; mounted specimens of grizzly bear, Rocky Mountain sheep and goats, heads of buffalo, specimens of several species of deer and various smaller animals from the Rocky Mountain region; several hundred birds donated by the Academy of Natural Sciences of Philadelphia and the Smithsonian Institution in exchange for other specimens; unusually fine specimens of skeletons and crania of over one hundred species of mammals, birds and reptiles, and the fine collection of Dr. Pope of choice mounted skeletons of mammals purchased in Europe; several hundred plants

collected around St. Louis and in Louisiana in 1828-29 by the Right Reverend Rosati, Bishop of St. Louis; a valuable collection of marine and fresh water shells; insects, especially those injurious to vegetation; star fishes and sea urchins; and an extensive series of lichens and mosses, chiefly from western states and territories, and papier maché models of fungi, colored true to nature, presented by Dr. T. C. Hilgard.

Here were to be found distorted crania from mounds near Little Rock, Arkansas, also stone axes, spear and arrow heads, quoits, shells and beads and other aboriginal implements and ornaments from western states, Indian costumes, war implements, cooking utensils and ornaments of the Upper Missouri Indians; a beautiful series of porcelain ornaments in bas-relief, representing figures of men and animals, and used as decorations in the great Porcelain Tower of China; also highly polished bricks employed in its construction.

During the years that the Academy was tenanted in the Public School Library Building, the Washington University, and the Missouri Historical Society, what was left of the museum and such small accessions as were acquired from time to time were stored in basements, and, consequently, of no use to the members or to the public.

However, during the bright days of the Archaeological Section in 1876 and 1877, excavations were made by the Academy in the mounds of southeastern Missouri, in northern Arkansas and in Illinois, the partial results of which were published in a quarto memoir. The pottery and the crania obtained then are among the treasures of the present museum.

In 1900 the Academy purchased the Yandell Collection of palaeontological specimens, containing many of Yandell's own type specimens and of those described by Shumard, whose collection is owned by Washington University. This collection is especially rich in Crinoids of the Devonian Age and many rare types contained in it are described in the first volume of the Transactions.

The purchase of this collection by the Academy placed in St. Louis two of the best fossil collections in existence to which students may refer in their scientific researches for typical specimens characteristic of this section of the country.

In 1901, through the efforts of Mrs. Wm. L. Bouton, the Academy acquired a collection of six hundred and thirty-five butterflies, mostly tropical.

When the Academy moved into its own home in 1903 new efforts were made to again establish a museum of natural history worthy of the name. Besides the Yandell and butterfly collections, the Academy has on exhibition a fine collection of mound builder pottery and some forty human skulls from the mounds near New Madrid, Missouri; a collection of song birds and birds of prey, deposited with the Academy by the Missouri Botanical Garden; many minerals from all parts of the United States; a small collection of fossil leaves; a collection of twenty-five meteorites, among them a section of the Fort Pierre meteorite; some fine fossiliferous slabs, mostly from St. Louis limestone and of great value; some of the fossils of the Hayden Survey, containing the type of *Titanotherium Proutii;* and a good specimen of *Bos cavifrons* (a species of fossil ox).

Hand in hand with the formation of a museum went the acquisition of a library. In the first year of its existence the Academy received the library, consisting of one hundred twenty volumes, of the Western Academy of Natural Sciences. With this as a nucleus, efforts were made to secure the publications of other scientific societies. Letters were sent to kindred societies and the exchange value of publications soon became evident. A committee was appointed to consider the question of undertaking some form of publication. After considerable thought and discussion the publication of "Transactions" was decided upon, and the first number was issued early in 1857. It contained in addition to the charter, constitution and by-laws, and journal of proceedings,

the following articles:—On some new species of fossils from the Cretaceous formation of Nebraska Territory, by John Evans and B. F. Shumard; Description of a new species of Productus from the Carboniferous limestone of St. Louis, by Hiram A. Prout; Observations on glycerin, by James Schiel; Phyllotaxis—its numeric and divergential law explicable under a simple organological idea, by T. C. Hilgard; Mastodon remains, in the State of Missouri, together with evidences of the existence of Man contemporaneously with the Mastodon, by Albert C. Koch; Notice of a burnt brick from the ruins of Nineveh, by G. Seyffarth; Indian stone graves in Illinois, by A. Wislizenus; Description of new fossil Crinoidea from the Palaeozoic rocks of the western and southern portions of the United States, by B. F. Shumard; Belcher and Brothers Artesian well, by A. Litton; Meteorological observations for 1856 made in St. Louis by Drs. Engelmann and Wislizenus.

Since its organization the Academy has issued twenty-two volumes of Transactions, and on two occasions special works. One, entitled "Contributions to the Archaeology of Missouri" by the Archaeological Section, is devoted to the description and illustration of the pottery obtained by a party from the Academy which investigated the mounds in the neighborhood of New Madrid. In 1889 the Academy sent observers into the field to study the total eclipse of that year. Their report, entitled "Total Eclipse of the Sun, January, 1889. A report of Observations made by the Washington University Eclipse Party at Norman, California," was published by the Academy in a quarto of 39 pages and 6 plates.

While no serious efforts were made after the fire of 1869 during some thirty years to re-establish the museum, the energies of the Academy during that time were devoted to the formation of a library by the liberal exchange of publications. The first society to recognize the new organization was the Academy of Natural Sciences of Philadelphia, which donated to the library a set

of its "Proceedings" and the second series of its "Journal." By exchange the Academy has received many valuable series issued by kindred societies all over the world, most of which have been received without interruption and prove indispensible to investigators who desire to go into the earlier literature of their subjects. Today publications are exchanged with 306 foreign and 114 home societies.

The growth of the Academy in recent years has been essentially along the lines defined by its founders. Its library has been steadily increased through its affiliations with other scientific bodies in this and foreign countries; its collections are housed and its meetings held in its own building; and the Transactions have been published in unbroken series and kept up to a high and worthy standard.

As the present must ever be accumulating knowledge for the future, the influence of the Academy of Science will grow greater and greater as the years go by, bringing within its folds all those interested in the development of science, fostering and strengthening the scientific spirit, and passing on from generation to generation the achievements of science, as expressed in its motto, "for human knowledge and power."

Issued December 29, 1914.

Transactions of The Academy of Science of St. Louis.

VOL. XXIII. No. 3.

THE AGAVEAE OF GUATEMALA.

WILLIAM TRELEASE.

Issued July 15, 1915.

THE AGAVEAE OF GUATEMALA.*

WILLIAM TRELEASE.

The records of *Agave* and *Furcraea* as Guatemalan plants are neither extensive nor convincing. Hemsley in his summary of Central American plants attributes *Agave Sartorii* and *A. Seemanniana*[1] to Guatemala, as he does *Furcraea longaeva* and *F. Selloa.*[2]

Agave Sartorii is a species characteristic of the forests of the coastwise flanks of Mt. Orizaba, Mexico, where, as Roezl[3] notes for *A. attenuata,* and as I have myself observed about Cuernavaca, in western Mexico, for *A. Mescal,* it is sometimes epiphytic. The name given it is commemorative of Sartorius, a German settler, whose hacienda El Mirador at Huatusco, in the Mexican state of Vera Cruz, is the type locality of numerous species collected either by him or by the botanical guests who even yet make it their headquarters. The only reason for supposing that *A. Sartorii* occurs in Guatemala lies in the statement of its describer[4] that it was sent by Rohrbach to Berlin from Orizaba, and also by Sartorius to Darmstadt from the same place *or from Guatemala.*[5] *Agave Seemanniana* is said

*Presented before The Academy of Science of St. Louis, June 7, 1915.

[1] Biologia Centrali-Americana. 3: 349.
[2] *l. c.* 3: 353.
[3] Roezl, Belgique Horticole. 1882: 98.
[4] Koch, Wochenschr. Verein Beförd. Gartenbau. 3: 37. 1860.
[5] "Andernseits wurde sie durch den Reisenden Sartorius eben daher oder aus Guatemala an den Garten-director Noack in Darmstadt gesendet."

by its describer[6] to have been discovered by Dr. Berthold Seemann in the colony of New Segovia in the republic of Guatemala and introduced by him into English gardens by means of seeds. I do not know of a Guatemalan town called Segovia, however, and the seedsman who first advertised the plant in the autumn of 1867 as *A. Seemanni*,[7] says that it was collected by Seemann in stony places in the department of Matagalpa, Nicaragua—which, indeed, is adjacent to Segovia. There seems to be no evidence therefore that *A. Sartorii* is Guatemalan; but what is taken for *A. Seemanniana* does occur in eastern Guatemala, some 300 miles northwest of the Nicaraguan region from which it really seems to have been described.

Herbaria, so far as I have seen them—and I have examined the principal collections of the world, give as little evidence as do publications that the genus *Agave* occurs in Guatemala, except that of late years several amiable correspondents have sent me specimens that are preserved at the Missouri Botanical Garden.

My own connection with the matter dates from the early part of 1901, when I observed several rosette-forming agaves along the trail from El Rancho, on the Motagua River—where the railroad from Puerto Barrios then stopped—to the capital. At that time I was making a hurried survey of the distribution of *Yucca guatemalensis* (or *elephantipes*), and collected no agaves, and it was not until the present spring that I found opportunity to study these plants through a short leave of absence kindly granted by the President and Trustees of the University of Illinois, supplemented by an honorary commission from the Secretary of Agriculture of the United States. The following pages summarize what I have been able to ascertain in the field and from a study of the specimens that were sent me while I was

---

[6] v. Jacobi, Abhandl. Schles. Gesellsch. 1869: 154.
[7] Bull, List. 22: 3.

at the Missouri Botanical Garden, for the use of which I am indebted to the present Director of the Garden.

From repeated observations on the Mexican species of this genus and the conspicuous localization of those of Baja California[8] and the West Indies,[9] I have been quite prepared to find that in Guatemala the agaves are distinctly different—not only in species but in characteristic groups—from those of Mexico, while differing even more markedly from those of the Antilles. Unfortunately the greater number of those here reported must be differentiated on vegetative characters only, so that it is quite within the range of possibility that some of them may be found divisible when added material comes to hand. I have shown in earlier studies[10] that the characters derivable from the arming of the leaves in this genus are remarkably constant, and the foliage indications are that all of the Guatemalan species are Euagaves.

My personal opportunities for study and collection in Guatemala have extended only to the central mountain region, in which a marked division of the year into a rainy and a dry season occurs, the contrast between which is so great that the majority of plants lose their foliage and pass into a dormant state, with well developed scaly buds, for the long dry season, just as our northern plants hibernate, though the Guatemalan temperature may be even higher than in the rainy season. So far as I know, none of the agaves occur spontaneously at less than about 2000 feet above sea level, though one cultivated species does well to within a few hundred feet of the sea on the Pacific slope. That the dry region about Salamá, which I have not been able to visit, may furnish other species is very probable, and almost half

---

[8] Trelease, Rept. Mo. Bot. Gard. **22**: 38-41. 1912.

[9] Trelease, Memoirs Natl. Acad. Sci. **11**: 6-11, etc. 1913.

[10] Trans. Acad. Sci. St. Louis. **18**: 31. 1909.—Proc. Amer. Philos. Soc. **49**: 232-7. 1910.—Mem. Natl. Acad. Sci. **13**: 12. 1913.

of the Republic, West of British Honduras, is unexplored; the prospect, nevertheless, is that the total number of agaves indigenous to Guatemala will scarcely be found to double the number now reported. For the convenience of those whose interest includes the parks or other public places of the capital or experimental plantations of fiber plants, I have included in the following treatment the very few cultivated agaves that I have seen in Guatemala.

The most striking geographic fact revealed by what are now known is undoubtedly that the spicate subgenus of *Agave*, Littaea, does not appear to reach into Central America any more than into the West Indies;—though as Littaeas occur in the southern Cordillera of Mexico there would be nothing surprising if some of them were to be found in the Guatemalan continuation of those mountains.

The *Furcraea* records for Guatemala are scarcely more convincing than the *Agave* records. *F. longaeva*, the most remarkable representative of its genus if not the most noteworthy lilioid plant, figures in one of the vignettes of Bateman's superb work on orchids,[11] and is said to have been seen by Skinner in the high mountains of that country. There is no improbability in this, since its type locality is the cordillera of Oaxaca in adjacent Mexico in which region it has been recollected recently.[12] At first sight, *F. Selloa* seems to be even more definitely fixed as Guatemalan, for its author, though describing it from a specimen cultivated in Europe, states that it was collected by von Warscewicz on the volcano of Quassaltenango, Guatemala.[13] Of recent years, that caulescent garden *Furcraea* that Mr. Baker took for *cubensis* has generally been accepted as *F. Selloa;* there is reason to believe that this comes from Co-

---

[11] Bateman, Orchid. of Mex. & Guatemala. Vignette to *pl. 16.* 1843.
[12] Purpus, Möller's d. Gärtn.-Zeit. **26**: 10. *f. 1-3.* 1911.
[13] Koch, Wochenschr. Verein Beförd. Gartenbau. **3**: 22. 1860.

lombia; and Mr. Drummond, in his summary review of the genus,[14] expresses the opinion that its Guatemalan origin seems to require verification. Accepting this view, particularly as the descriptions of *F. Selloa* do not well fit the only species of the Quezaltenango region —which is very clearly distinct from what is commonly cultivated as *F. Selloa,* I should say that as yet none of the larger-toothed group Eufurcraea has been shown to be Guatemalan. Three such species actually occur in the Republic: one known only locally on the East slope; one extending from some 2500 feet altitude on the eastern slope through the district of Guatemala City at about 5000 feet to something like 2500 feet above sea-level on the western slope; and the third at rather higher altitudes in the mountains about Quezaltenango. The second and third of these are somewhat abundant, especially the second, and a good deal of fiber is prepared from them by crude means, though not on a commercial scale. Both are called "maguey", like the agaves. In contrast with this, the single representative of the unarmed group Serrulatae that I know as Guatemalan is called "cheech"; this is said by its collector to furnish a sort of crude cordage.

The habitats of both *Agave* and *Furcraea* in Guatemala correspond to what is known of them elsewhere. *Agave,* distinctly northern, represented, as has been said, by its larger section Euagave and usually strongly xerophytic, occurs in gravelly or stony places, on the sides of barrancas, etc., and less commonly on the faces of rocky cliffs than in Mexico. *Furcraea,* a distinctly southern genus, more frequently found in timbered regions, here also affects the wooded adobe hillsides unless, as seems probable, the more xerophytic Serrulatae occur here as to the north in more open and better drained soil.

---

[14] Rept. Mo. Bot. Gard. 18: 45. 1907.

SYNOPSIS OF GUATEMALAN AGAVES.

Rather small plants with somewhat fleshy lanceolate to obovate leaves and, so far as known, narrowly oblong panicles with the flowers densely clustered at the ends of their branches.—Indigenous. GUATEMALENSES.

Leaves relatively broad.
- Spine flat-grooved, with acute edges.
  - Very tortuous or twisted, brown. *A. tortispina.*
  - Nearly straight.
    - Gray-brown; teeth heavy. *A. pachycentra.*
    - Chestnut; teeth slender. *A. Hurteri.*
- Spine involute-grooved; teeth small, often on fleshy elevations. *A. Seemanniana.*

Leaves relatively narrow.
- Spine involute-grooved, conical or acicular.
  - Teeth small.
    - Leaves numerous, ascending. *A. Thomasae.*
    - Leaves few, spreading. *A. Deamiana.*
  - Teeth moderate, easily falling. *A. minarum.*
  - Teeth large, brown.
    - Spine long acicular. *A. tenuispina.*
    - Spine heavily conical. *A. opacidens.*
- Spine nearly flat on the face. *A. sicaefolia.*
- Spine round-grooved.
  - Teeth close together, chestnut.
    - Slender-cusped from blue bases. *A. Kellermaniana.*
    - Heavily triangular. *A. samalana.*
  - Teeth widely separated, red-brown. *A. lagunae.*

Rather large plants with fibrous sword-shaped leaves and, so far as known, open panicles with the flowers loosely grouped at the ends of their branches.—Cultivated in hedges or for fiber.

Spine short-conical.—SISALANAE.
- Leaves very glaucous, deeply concave. *A. nivea.*
- Leaves gray-green, nearly flat. *A. sisalana.*

Spine heavy awl-shaped.—TEQUILANAE. *A. Donnell-Smithii.*

Large plants with fleshy lanceolate leaves and open panicles with the flowers rather loosely grouped at the ends of their branches.—Introduced.

Leaves broadly oblanceolate, upcurved at tip.—ATROVIRENTES.
- Spine long-conical, narrowly grooved. *A. tecta.*

Leaves elongated lanceolate, recurving.—AMERICANAE.
- Spine stout-conical, recurved. *A. americana.*
- Spine acicular, straight. *A. picta.*

Agave tortispina n. sp.

Acaulescent, not cespitose. Leaves white-glaucous on a yellow-green ground, more or less transversely banded, forming a close rosette, broadly oblanceolate-spatulate, subacuminate, somewhat concave, slightly granular beneath, 10×25–30 cm.: spine red-brown becoming smoky, glossy, slightly granular below, very tortuous, very openly grooved from above the middle with acute edges, ventrally and dorsally keeled, decurrent for scarcely its own length, somewhat intruded into the green tissue on both faces, 4×30 mm.: teeth similarly colored, 15–25 mm. apart, 3–5 mm. long, nearly straight, broadly triangular, rather gradually dilated into the tops of high green prominences between which the margin is nearly straight, or which are separated by acute sinuses. Inflorescence, flowers and fruit unknown.

Specimens examined: GUATEMALA. Cruz, between El Rancho and Sanarate (*Trelease, 1,* March, 1915—the type in the herbarium of the University of Illinois).

Agave pachycentra n. sp.

Acaulescent, little suckering. Leaves very blue-glaucous on a deep green ground, ascending in a close rosette, broadly oblong-oblanceolate, acute, concave, minutely granular beneath, 15–20×35–60 cm.: spine drab or graying, dull or slightly glossy, more or less granular, stoutly half-conical or triquetrous, somewhat wavy, very openly grooved from near the end with acute edges, usually ventrally and dorsally keeled, decurrent for about its own length, more or less intruded into the green tissue on both faces, 8×50–60 mm.: teeth similarly colored, rather dull, mostly 25–40 or 50 mm. apart, 5–10 mm. long, more or less curved, especially downward, heavily triangular, abruptly dilated into fleshy prominences or frequently shouldered at base, the intervening margin somewhat concave. Inflorescence, flowers and fruit unknown.

Specimens examined: GUATEMALA. Cruz (*Trelease*, 2, March, 1915—the type in the herbarium of the University of Illinois).

39 **Agave Hurteri** n. sp.

Acaulescent, not cespitose. Leaves somewhat glaucous, ascending or outcurving in a rather dense rosette, lance-oblong, rather acute, openly concave, smooth, some 10×75–100 cm.: spine chestnut, glossy above, somewhat pitted below, heavily half-conical, nearly straight, very openly grooved from near the end, usually with median keel, the very acute edges decurrent for about its length, more or less intruded into the green tissues on both faces, about 8×40 mm.: teeth similarly colored, 10–20 mm. apart, 5–10 mm. long, straight or mostly variously curved, the narrowly triangular cusps lenticularly dilated into the straight pale-denticulate margin. Inflorescence about 5 m. high, the upper third or half oblong-paniculate with slender outcurved branches at the ends of which the flowers are densely clustered: bracts narrowly triangular, spreading: pedicels thick, 5–10 mm. long, densely invested by short bracts. Flowers greenish white or pale yellow, 60–70 mm. long: ovary 25–30 mm. long, shorter than the perianth, oblong: tube narrowly conical, 12–15 mm. deep: segments more yellow, 25 mm. long, nearly equaling the ovary: filaments inserted nearly in the throat, 60–70 mm. long, maroon-dotted like the style. Capsules oblong, 20×50 mm., neither stipitate nor beaked: seeds 5×8 mm. Apparently not bulbiferous.

Specimens examined: GUATEMALA. Zunil, on the Samalá River (*Trelease, 3*, April, 1915—the type in the herbarium of the University of Illinois).

Dedicated to Señor Don G. Hurter, of Quezaltenango, who has made exquisite photographs of this and other plants characteristic of this part of Guatemala.

Agave Seemanniana Jacobi.

Agave Seemanni Bull, List. 22:3. 1867; also 34:26, 45:18, 49:23.

No doubt too incompletely characterized to fix this spelling of the name, which nevertheless is still well established in gardens—*e. g.* Finckh, Gard. **51: 407.** *f.* **(1897).**

1447 *A. Seemanniana,* **Jacobi, Ablandl. Schles. Gesellsch. 1869: 154.**

Acaulescent, not cespitose. Leaves glaucous, somewhat green-banded, openly spreading, oblanceolate-oblong or obovate, acute or subacuminate, minutely roughened toward the apex, 8×35 cm.; spine purplish brown, somewhat glossy above, minutely granular below, slenderly conical or acicular, more or less flexuous, involutely grooved from above the middle with acute edges, decurrent for its own length or less, scarcely intruded into the green tissue, 2–4×20–30 mm.: teeth brown or turning gray, 10–20 mm. apart, 2–3 mm. long, rather straight but the lower pointing downwards, the slenderly triangular cusps abruptly dilated onto the tops of fleshy prominences between which the somewhat concave margin sometimes bears slender dark denticles. Inflorescence said by the collector to be 2 m. high. From the illustration of a specimen flowering in Sydney, N. S. W., the inflorescence is 5 m. high, the oblong panicle with densely bunched flowers occupying three-fourths of its length, and the short scape with broad bracts.

Specimens examined: Guatemala. Fiscal (*Deam, 6154,* June, 1909). Without data, living plants (Missouri Botanical Garden, 1887; Kew, *no. 271/97,* 1905). A specimen with the spine-base heavier than usual, but referred here, occurs without data in the herbarium of the Missouri Botanical Garden (*Norton, 2,* Feb., 1912),

2368 and may be called var. **perscabra.**

That *A. Seemanniana* may have been introduced into cultivation in the form of plants as well as seeds is suggested by Ellemeet's[15] reporting soon after its introduc-

---

[15] **Belgique Horticole. 1871: 118.**

tion that a specimen had flowered with him and was still alive a year later. The only other records of its flowering, respectively on the Riviera[16] and in New South Wales,[17] make no mention of this habit of surviving the flowering period; and it is possible that some other species was referred to by M. Ellemeet. That the seedlings at Bull's nurseries were very unlike was noted by Moore;[18] and as early as 1869-70 Bull advertised, with fair characterization, in addition to his typical *Seemanni* the varieties *acuta*, *papillosa* and *parvispina*. In the list of his own plants published in 1878, Peacock also mentions a variety *rotundifolia* of *A. Seemannii* as he calls it.

As has been stated above, *A. Seemanniana* seems to have Segovia, Nicaragua as its type locality, and so is to be sought in the mountains between this locality and the Motagua valley in Guatemala.

Agave Thomasae n. sp.

Acaulescent, suckering freely. Leaves clear green with dense easily removable striate bloom, ascending with outcurved tip, spatulate-oblanceolate, acute or somewhat acuminate, rather thin and flexible, concave, smooth above, finely roughened beneath, some 15×60 cm.: spine chestnut, somewhat roughened, acicular, nearly straight, involutely grooved below the middle with acute edges, little decurrent or intruded into the green tissue, 2×25 mm.: prickles chestnut, 5–10 mm. apart, 1–2 mm. long, nearly straight, the extremely slender cusps slightly dilated at base, the straight intervening margin with numerous minute needle-like denticles. Inflorescence, flowers and fruit unknown.

Specimens examined: Cultivated at the Hotel

---

[16] Baker, Kew Bull. 1892: 4; Add. Ser. 2: 220.
[17] Finckh, Garden. 51: 407. *f.* 1897.
[18] T. M., Gard. Chron. 1871: 74.

Thomas, Quezaltenango (*Trelease, 19,* April, 1915—the type).

Thinner-leaved and smaller-toothed than the Guatemalenses as otherwise known, and resembling certain of the Mexican aloid Littaeas—to which it may prove ultimately to belong. It is said to have come from the Guatemalan mountains, and is dedicated to Señora Dora Thomas, the possessor of the type plant.

336 **Agave Deamiana** n. sp.

Acaulescent, scarcely suckering. Leaves grayish or lightly glaucous, widely spreading, oblanceolate, acute, more or less concave, minutely roughened especially on the back and margin, some 10×100 cm.: spine purplish brown, somewhat glossy above, minutely granular below, slenderly conical or acicular, more or less flexuous, involutely grooved from about the middle with acute edges, decurrent for about its own length, scarcely intruded into the green tissue, 3–4×40 mm.: teeth chestnut, 10–20 mm. apart, 2–4 mm. long, straight or curved, especially downward, the slender triangular cusps lenticularly dilated into the straight margin. Inflorescence, flowers and fruit unknown.

Specimens examined: GUATEMALA. Sides of ravines, Fiscal (*Deam, 6154 a*—the type in the herbarium of the Missouri Botanical Garden; *6199, 6201;*—all in June, 1909).

1442 **Agave minarum** n. sp.

Acaulescent, scarcely cespitose. Leaves yellow-green, loosely spreading, lanceolate, acute, smooth, some 6×60 cm.: spine brown, glossy above, conical, smooth, nearly straight, round-grooved above becoming involute as the leaf dries, decurrent for rather more than its own length and somewhat dorsally intruded into the green tissue, 5×45 mm.: teeth easily detachable, 5–10 mm. apart, the intervening margin straight. Inflorescence 2 or 3 m.

high, loosely few-branched above with the flowers rather less compact than usual at ends of the slender spreading branches: pedicels 2×10 mm. Flowers yellow, 40 mm. long: ovary 20 mm. long, equaling the perianth, oblong-fusiform: tube conical, 6 mm. deep: segments 14 mm. long, shorter than the ovary: filaments inserted about the middle of the tube, some 30 mm. long, twice as long as the segments. Fruit unknown.

Specimens examined: GUATEMALA. Sierra de las Minas, opposite El Rancho, at 2000 ft. altitude (*Kellerman, 5129,* March, 1905—the type, as sheet *no. 576,279* in the U. S. National Herbarium). What is taken for the same species occurs on the rocks along the Motagua River about San Pablo, below Gualan.

1450 **Agave tenuispina** n. sp.

Acaulescent, scarcely cespitose. Leaves glaucous, forming a rather compact rosette, oblanceolate, acute, smooth, about 20×70 cm.: spine dull brown, acicular, smooth or somewhat roughened at base, slightly undulate, involutely grooved from above the middle with rather blunt edges, decurrent for scarcely half its length and not intruded into the green tissue, 3×60–70 mm.: teeth brown, somewhat glossy, 20–40 mm. apart, 5–10 mm. long, curved in either direction, rather narrowly triangular, somewhat deltoidally enlarged into fleshy prominences between which the margin is somewhat concave, or into the otherwise nearly straight margin. Inflorescence, flowers and fruit unknown.

Specimens examined: GUATEMALA. Mountainsides at Cruz (*Trelease, 4,* March, 1915—the type in the herbarium of the University of Illinois).

1444 **Agave opacidens** n. sp.

Acaulescent, scarcely suckering. Leaves glaucous, lanceolate, acute, roughened on the back and margin,

8–10×75 cm.: spine dull brown, quickly graying, granular below, stoutly triquetrous-conical, nearly straight, involutely grooved from above the middle with acute edges, decurrent for once or twice its length, somewhat dorsally intruded into the green tissue, 3–6×50–60 mm.: teeth drab, rather dull, 20–50 mm. apart, 5–8 mm. long, nearly straight, heavily triangular, dilated lenticularly into more or less elevated prominences of the otherwise nearly straight margin. Inflorescence about 5 m. high, the upper half oblong-paniculate: bracts broadly triangular, appressed: pedicels about 10 mm. long. Flowers yellow, 40–45 mm. long: ovary 25–30 mm. long, rather exceeding the perianth, fusiform: tube openly conical, 10 mm. deep: segments 5×12–15 mm., half as long as the ovary: filaments inserted about the middle of the tube, 35 mm. long. Capsules oblong, stipitate, 20×40–45 mm.: seeds 5×6 mm. Apparently not bulbiferous.

Specimens examined: GUATEMALA. Cruz (*Trelease, 5,* March, 1915—the type in the herbarium of the University of Illinois).

1448 **Agave sicaefolia** n. sp.

Acaulescent, very cespitose. Leaves gray-green rather than glaucous, forming a dense cluster, lanceolate, acute or slightly acuminate, nearly flat to deeply concave, slightly granular on the back above, 7–8×60–75 cm.: spine purplish chestnut fading to gray-brown, rather glossy, granular below, triquetrous, nearly straight, flattened or very openly grooved, often with median keel, from near the very sharp end, with acute short-decurrent margin, somewhat intruded into the green tissue both dorsally and ventrally, 4×30–40 mm.: teeth similarly colored, somewhat glossy, 15–35 mm. apart, 3–5 mm. long, mostly upcurved, the rather slender sometimes hooked cusps lenticularly dilated, the rather concave intervening margin sometimes with one or more

minute brown needles. Inflorescence, flowers and fruit unknown.

Specimens examined: GUATEMALA. Hillside at El Rancho (*Trelease, 6*, April, 1915,—the type in the herbarium of the University of Illinois).

Agave Kellermaniana n. sp.

Acaulescent. Leaves very glaucous, elongated-lanceolate, slightly acuminate, rather concave, somewhat minutely granular on the back above, 8–10×100 cm. or more: spine purplish chestnut, somewhat glossy, granular below, slenderly conical, sometimes slightly flexuous, round-grooved from above the middle with rather blunt edges, decurrent for once or twice its length, somewhat dorsally intruded into the green tissue, 4–5×30–35 mm.: teeth 10–25 mm. apart, 3–5 mm. long, upcurved, the rather slender glossy purple-chestnut cusps with abrupt blue bases either occupying the larger part of fleshy prominences or lenticular in the straight margin. Inflorescence, flowers and fruit unknown.

Specimens examined: GUATEMALA. Sides of ravines, at 3700 ft., Fiscal (*Deam, 6239*, June, 1909—the type, at the Missouri Botanical Garden). Without data (*Norton*, 1912).

Agave samalana n. sp.

Acaulescent, scarcely suckering. Leaves glaucous, especially beneath, rather numerous, oblanceolate, subacuminate, somewhat concave, minutely roughened beneath and on the margin, finally some 15×60 cm.: spine reddish becoming darker, somewhat glossy, typically granular below, slenderly conical or acicular, nearly straight, round-grooved from above the middle with acute edges, decurrent for something like its own length, more or less intruded into the green tissue dorsally, 3–4 ×35–55 mm.: teeth chestnut, dull, 5–10 or 20 mm. apart, 1–3 or 5 mm. long, straight or gently upcurved, trian-

gular, rather lenticularly widened into the nearly straight denticulate margin. Inflorescence 3–4 m. high, the upper half narrowly paniculate with extremely short branches. Flowers (?). Capsules oblong, 2×5–6 cm., campanulately dehiscent, reticulate: seeds 5×7 mm.—Specimens examined: Guatemala. Mountainsides along the Samalá River about Esperanza, between Sta. Maria and Zunil (*Trelease, 7, 9,* April 10, 1915—the types in the herbarium of the University of Illinois; *8,* April 4, 1915).

(443) **Agave lagunae** n. sp.

Acaulescent, scarcely suckering. Leaves very glaucous, spreading, lanceolate, acute, moderately concave, more or less minutely granular on the back and margin, 8–10×30–40 cm.: spine garnet, glossy, granular below, conical, often slightly flexuous, round-grooved from near the very sharp tip with acute shortly decurrent edges, somewhat dorsally intruded into the green tissue, 3–5×20–30 mm.: teeth similarly colored, glossy, 20–40 mm. apart, 3–5 or 6 mm. long, mostly upcurved above and partly recurved below, the rather slender mostly hooked cusps lenticularly widened into the margin or on the tops of fleshy prominences between which the margin is nearly straight. Inflorescence, flowers and fruit unknown.

Specimens examined: Guatemala. Above Amatitlan, near the lake (*Trelease, 10,* April, 1915—the type, in the herbarium of the University of Illinois). Palin to Escuintla (*De Ham,* 1908; *Kradolfer,* 1908).

On gravel, talus and cliffs, in the region between Amatitlan and Palin on the flanks of the Volcan de Agua, on the Pacific slope.

443 **Agave nivea** n. sp.

Acaulescent, suckering. Leaves very glaucous, somewhat transversely green-banded, narrowly lanceolate,

ascending, acute, very concave so as to appear oblong, minutely granular on the back and margin, at length 15×200 cm.: spine black-chestnut, somewhat glossy, finely pitted, slenderly conical, more or less laterally curved, very shallow grooved near the base, 3×15–20 mm., scarcely decurrent or intruded: teeth similarly colored, rather glossy above, 30–50 mm. apart, about 3 mm. long, mostly upcurved, the often curved or flexed slender cusps deltoidally broadened below and often from somewhat raised fleshy bases between which the margin is nearly straight. Inflorescence said to be an open panicle of yellowish flowers accompanied or followed by bulbils.

Specimens examined: GUATEMALA. About El Rancho (*Trelease, 11,* April, 1915—the type in the herbarium of the University of Illinois; *12, 13*).

Known to me only as planted in hedge-rows or clearly escaped, but said to be spontaneous in the mountains to the north: perhaps really of the endemic alliance.

AGAVE SISALANA Perrine.

Agave sisalana Perrine, House Doc. no. 564:8; Senate Doc. no. 300:36. *pl. 1-2.* 1838.—This species is contrasted with its immediate relatives in Mem. Nat. Acad. Sci. 11: 47. 1913.

Subacaulescent, suckering. Leaves sword-shaped, lightly glaucous becoming green: spine chestnut, pitted, tumidly conical, gently recurved, shallowly round-grooved toward the base, neither decurrent nor intruded into the green tissue: teeth small and slender or typically nearly or quite wanting, the margin nearly straight.

The Sisal, yaxci or green agave, here called henequen and occasionally planted for its fiber, *e. g.*, Cruz (*Trelease, 14*): originally from Yucatan.

1433 **Agave Donnell-Smithii** n. sp.

Acaulescent, suckering freely. Leaves light green

and somewhat whitened above, glaucous beneath, ascending, sword-shaped, moderately concave, smooth, 8× 75–100 cm. or longer: spine garnet becoming chestnut, glossy, smooth, stoutly awl-shaped, slightly curved, terete, flat or shallow-grooved near the base, neither decurrent nor intruded into the green tissue, 4×12–15 mm.: teeth similarly colored, 10 or 15–25 or 30 mm. apart, 2–3 mm. long, upcurved, triangular, lenticularly dilated into the straight margin. Inflorescence paniculate: pedicels 5–10 mm. long. Flowers greenish yellow, 40–45 mm. long; ovary 20–25 mm. long, about equaling the perianth, oblong-fusiform: tube suburceolate, some 8 mm. deep: segments 15–20 mm. long, shorter than the ovary, brighter colored than the tube: filaments inserted above the upper third of the tube, 35 mm. long, twice as long as the segments. Fruit unknown. Bulbiferous(?).

Specimens examined: GUATEMALA. Hedges about Escuintla (*Smith, 2085*—the type in the U. S. National Herbarium; *Trelease, 15*, 1915). Mixco (*Trelease, 16*, 1915). Fiscal (*Deam, 6240*, June, 1909). Also seen in cultivation in the Plaza de Armas, Guatemala City, at Guarda Viejo, and on the Pacific slope as far down as Palo Gordo near Mazatenango.

Apparently of the alliance of *A. tequilana* and *A. Zapupe* of Mexico, and of doubtful origin; but the Fiscal specimens, from ledges in a cañon, should be wild. The group is not unknown in the Pacific region to the South.

1449 **Agave tecta** n. sp.

Acaulescent, suckering. Leaves grayish green, broadly oblanceolate or at first almost obovate, ascending, the gradually subacuminate apex sigmoidally upcurved, concave, valleculate above, smooth, becoming 50×200 cm.: spine purple-chestnut becoming gray, dull, smooth, conical or subacicular, often compressed, slightly flexuous, shallowy grooved below the middle, 5–7×45–65 mm.,

long-decurrent, somewhat intruded dorsally into the green tissue: teeth similarly colored, more or less polished, 40–70 mm. apart, about 8 mm. long, recurved, the triangular often curved cusps abruptly dilated into low bases 15 mm. or more wide, between which the smooth margin is nearly straight. Inflorescence 5–6 m. high, the upper half ellipsoidally paniculate with slightly ascending branches: bracts broadly triangular, densely imbricated so as to cover the scape completely, those of the panicle reduced and spreading: pedicels thick, 5–10 mm. long. Flowers yellow, about 70 mm. long: ovary 30–35 mm. long, about equaling the perianth, oblong: tube openly conical, 10–15 mm. deep: segments about 20 mm. long, shorter than the ovary: filaments inserted about the middle of the tube, some 40 mm. long. Capsules (immature) oblong, some 30×60 mm. Apparently not bulbiferous.

Specimens examined: Guatemala. About Quezaltenango (*Trelease, 17*—the type, in the herbarium of the University of Illinois; *18*, both in April, 1915).

Known to me only as planted in hedge-rows, sparingly in the vicinity of Mixco, between Antigua and the capital—and in gardens in the latter, but abundantly in and about Quezaltenango, north of which it is said to occur wild in the mountains. Evidently of the group Atrovirentes, to which the pulque species of Mexico belong,—the type of which, *A. atrovirens*, like *Furcraea longaeva*, was described from Mt. Tanga in southern Oaxaca.

Though pulque is now unknown in Guatemala, Fuentes y Guzman, "regido perpetual de la ciudad de Goathemala," records that excellent pulque was produced at Atmolonga or Ciudad Vieja and at San Gaspar two centuries ago;[19] but there remains no evidence of it that I have been able to discover unless it be in these scattered hedge-rows of *Agave tecta*.

---

[19] Fuentes y Guzman, Recordacion Florida. 1: 289. Madrid, 1882,—the manuscript written in 1690.

37/ AGAVE AMERICANA L.

Leaves lanceolate, narrowly so in age, usually hooked toward the end, gray-green: spine stoutly conical, gently recurved, narrowly grooved below the middle, scarcely decurrent: teeth narrowly triangular, hardened into the tops of fleshy prominences between which the margin is more or less concave.

The most frequently planted *Agave*, in Guatemalan parks represented by the white- or yellow-margined variety, var. *marginata*.

1445 AGAVE PICTA Salm.

Differing from *A. americana marginata* in its darker green leaves and slender acicular straight spine.

The unvariegated form of this, which occurs about the Mediterranean from seeds of the variegated form, has been called *A. ingens* by Mr. Berger: it is not known elsewhere.

The variegated form is sparingly cultivated in Guatemala,—*e. g.* about the railroad yards in the capital.

SYNOPSIS OF GUATEMALAN FURCRAEAS.

Leaves rough-margined but without large teeth, glaucous, striate-roughened. Caulescent.—SERRULATAE.

Tall tree. Flowers pubescent.	*F. longaeva.*
Scarcely 2 m. high. Flowers glabrous.	*F. quicheensis.*

Leaves smooth-margined, toothed, green or little glaucous, not striate. Often acaulescent.—EUFURCRAEA.

Teeth usually confined to the lower third of leaf.	*F. samalana.*
Toothed throughout.	
Teeth red or brown, rather distant. Leaves flattish.	*F. guatemalensis.*
Teeth blackish, close together. Leaves very concave.	*F. melanodonta.*

1459 FURCRAEA LONGAEVA Karwinski & Zuccarini.

Furcraea longaeva Zuccarini, Acta Acad. Caes. Leop.-Carol. 16²: 665. *pl. 48.* 1833.—As with other species, the generic name is variously spelled *Furcraea, Furcroea* and *Fourcroya;* and the specific name has been transformed into *longa* by Smith, Teysmannia. 7: 131. 1897.

Arboreous, the unbranched trunk becoming 15 m. or more high. Leaves gray, outcurved, lanceolate, subacuminate, concave, 8–15×200 cm., minutely rough-margined. Inflorescence 5 m. high, broadly conical, short-stalked. Flowers 30–40 mm. long: ovary 20–25 mm. long, rather longer than the perianth. Capsules oblong, narrowed below: seeds 4×6 mm. Bulbils unknown.

Said to have been found by Skinner in the high mountains of Guatemala many years ago. The type was from Mt. Tanga, Oaxaca, at an altitude of 9,000–10,000 ft., and Purpus has rediscovered it on the Cerro de Besetla, in the Sierra de Mixteca, on the boundary between the Mexican states of Puebla and Oaxaca.

1461 **Furcraea quicheensis** n. sp.

Caulescent, the sometimes branched trunk little over 1 m. high. Leaves very pale green, heavily pruinose, lanceolate, acute, smooth, 10×120 cm., the thin subcartilaginous margin roughened at intervals of 1–2 mm. by minute straight yellowish denticles. Inflorescence 2.5–5 m. high, scarcely 1 m. wide with much reduced lower branches, subsessile (?): pedicels 7–10 mm. long, once or twice surpassed by the subtending bracts. Flowers 50–60 mm. long: ovary 25–30 mm. long, equaling the perianth: segments 6-8×25-30 mm., white-margined: filaments 10–12 mm. long. Capsules (immature) very narrowly oblong, 30×100–120 mm.: seeds and bulbils unknown.

Specimens examined: GUATEMALA. Between Quiché and Totonicapan (*Cook, n. b. 421,* May 17, 1906—the type, in the U. S. National Herbarium as sheet *number 692,146*).

1462 **Furcraea samalana** n. sp.

Acaulescent or caulescent with the trunk as much as 2 m. high. Leaves green or very slightly grayish, lanceolate, acute, nearly smooth, channeled with broad flat or outcurved margins, 10–15×150–200 cm.: spine scarcely 1×2 mm., acute, commonly abortive: teeth red-brown, usually absent or greatly reduced on the very long-acute upper part, 10–25 or 30 or even 60 mm. apart, slender, some 4 mm. long, mostly upcurved, decurrent on fleshy elevations between which the margin is concave when they are close together. Inflorescence 5 m. high, the upper three-fourths loosely oblong-paniculate. Flowers said to be greenish yellow. Capsules and seeds (?). Bulbils abundant, conical-ovoid, leafy-tufted, with dull gray-green scales.

Specimens examined: GUATEMALA. Samalá valley, between Sta. Maria and Zunil, etc. (*Trelease, 20,* April, 1915—the type in the herbarium of the University of Illinois; *21, 22, 29*).

1458 **Furcraea guatemalensis** n. sp.

Subacaulescent. Leaves rather dull green above and grayish beneath, lanceolate to typically almost sword-shaped, acute, smooth or very slightly roughened, moderately concave with somewhat outcurved margins, 10–15×200–225 cm.: spine scarcely 1×2 mm., awl-shaped: teeth red-brown, at first pale at base, later approaching chestnut, 10–25 or 30 mm. apart, some 3 mm. long, upcurved, decurrent on moderate fleshy elevations between which the margin is nearly straight. Inflorescence 5 m. high, loosely paniculate where exserted, glabrate. Flowers said to be greenish white. Capsules round-cuboid, stipitate and beaked, 50×50 mm.: seeds 12×20 mm. Bulbils abundant, round-ovoid, not leafy-tufted, the dark green scales very glossy.

Specimens examined: GUATEMALA. Guarda Viejo (*Trelease, 23,* April, 1915—the type in the herbarium of the

University of Illinois). Outskirts of Guatemala City (*Trelease, 24*). Palin (*Trelease, 25, 30*). Fiscal (*Deam, 6107, 6176-7*). Agua Caliente (*Deam, 6149*).

1460 **Furcraea melanodonta** n. sp.

Caulescent, the trunk scarcely over 1 m. high. Leaves gray or bluish on both faces, narrowly lanceolate, acute, slightly rough on both faces, deeply concave, 7–8×150 cm. or more: spine scarcely 2×2 mm., blunt, grooved at base, slightly decurrent: teeth blackish chestnut, 10 or 15 or sometimes 20 mm. apart, 5 mm. long, strongly upcurved, decurrent on fleshy elevations between which the margin is concave. Inflorescence, flowers, capsules and bulbils unknown.

Specimens examined: Guatemala. Cruz (*Trelease, 26*, March, 1915—the type in the herbarium of the University of Illinois).

EXPLANATION OF ILLUSTRATIONS.

Plate VI.—*Agave tortispina.* Above, the type at Cruz, Guatemala, with a small planted specimen of *A. sisalana* in the background, ×1/7. Below, spines and margin from the type (*Trelease, 1*), natural size.

Plate VII.—*Agave pachycentra.* Above, the type at Cruz, Guatemala, ×1/10. Below, spines and margin from the type (*Trelease, 2*), natural size.

Plate VIII.—*Agave Hurteri.* The type plant and two other flowering specimens, in the Samalá valley at Zunil, Guatemala, ×1/50.

Plate IX.—*Agave Hurteri.* Above, a panicle branch, showing the congested flowers characteristic of the Guatemalenses, ×1/3. Below, split and entire flowers, natural size. Both from the type (*Trelease, 3*).

Plate X.—*Agave Hurteri.* Spines, leaf-margin, capsules and seeds, from the type (*Trelease, 3*), natural size.

Plate XI.—*Agave Seemanniana.* Apex, margin and additional spines of the Guatemalan plant taken for this species (*Deam, 6154*), natural size.

Plate XII.—*Agave Thomasae.* Above, the type plant, at the Hotel Thomas, Quezaltenango, Guatemala—with a young plant of *A. americana marginata* in the foreground, ×1/15. Below, spine and prickles of the type (*Trelease, 19*), natural size.

Plate XIII.—*Agave Deamiana.* Above, representative plant, at Fiscal, Guatemala (*Deam*, photograph *6199*), ×1/15. Below, apex and margin of the type (*Deam, 6154 a*), natural size.

Plate XIV.—*Agave minarum.* Type sheet, reduced; and flowers of the type (*Kellerman, 5129*), natural size.

Plate XV.—*Agave tenuispina.* Type sheet, reduced; and spines and leaf-margin of the type (*Trelease, 4*), natural size.

Plate XVI.—*Agave opacidens.* Above, spines and leaf-margin. Below, dried flowers, capsules and seeds. Both from the type (*Trelease, 5*), natural size.

Plate XVII.—*Agave sicaefolia.* Above, the type clump at El Rancho, Guatemala. Below, spines and leaf-margin from the type (*Trelease, 6*), natural size.

Plate XVIII.—*Agave Kellermaniana.* Type sheet, reduced; and spine and leaf-margin of the type (*Deam, 6239*), natural size.

Plate XIX.—*Agave samalana.* Above, the type group of plants, ×1/100. Below, a representative plant, ×1/20. Between Zunil and Sta. Maria, in the Samalá valley, Guatemala.

Plate XX.—*Agave samalana.* Above, spines and leaf-margin, from the type (*Trelease, 7*). Below, shriveled flowers, capsules and seeds, from the type (*Trelease, 9*). Both natural size.

Plate XXI.—*Agave lagunae.* Above, the type plant on a gravelly slope above Amatitlan, Guatemala, ×1/10. Below, spines and leaf-margin from the type (*Trelease, 10*). Both natural size.

Plate XXII.—*Agave nivea.* Above, type plants in a hedgerow at El Rancho, Guatemala, ×1/30. Below, spines and leaf-margins from the type (*Trelease, 11*), natural size.

Plate XXIII.—*Agave Donnell-Smithii.* Plant in a hedge at Escuintla, Guatemala.

Plate XXIV.—*Agave Donnell-Smithii.* Above leaf arming from the type (*Smith, 2085*). Below, spines and portion of leaf from the plant pictured in *pl. 23* (*Trelease, 15*). Both natural size.

Plate XXV.—*Agave Donnell-Smithii.* Fragment of a panicle branch from the type (*Smith, 2085*), natural size.

Plate XXVI.—*Agave tecta.* Type group of plants in a hedgerow at Quezaltenango, Guatemala: the upper, ×1/60; the lower, ×1/30.

Plate XXVII.—*Agave tecta.* Spines, leaf-margins, bud, and imperfectly developed flowers, from the type (*Trelease, 17*—shown above in *pl. 26*), natural size.

Plate XXVIII.—*Furcraea longaeva.* A representative group of trees in the Mexican state of Oaxaca. Photographed by Dr. C. A. Purpus.

Plate XXIX.—*Furcraea quicheensis.* Flowers, and portion of leaf, of the type (*Cook, n. b. 421*), natural size.

Plate XXX.—*Furcraea samalana.* A flowering plant, in the vicinity of Quezaltenango, Guatemala. Photographed by Mr. G. Hurter.

Plate XXXI.—*Furcraea samalana.* Leaf-tips and margins, from the type (*Trelease, 20*), and bulbils, from a plant below Sta. Maria, Guatemala (*Trelease, 29*), natural size.

Plate XXXII.—*Furcraea guatemalensis.* The type plant, in a hedgerow near Guarda Viejo, Guatemala.

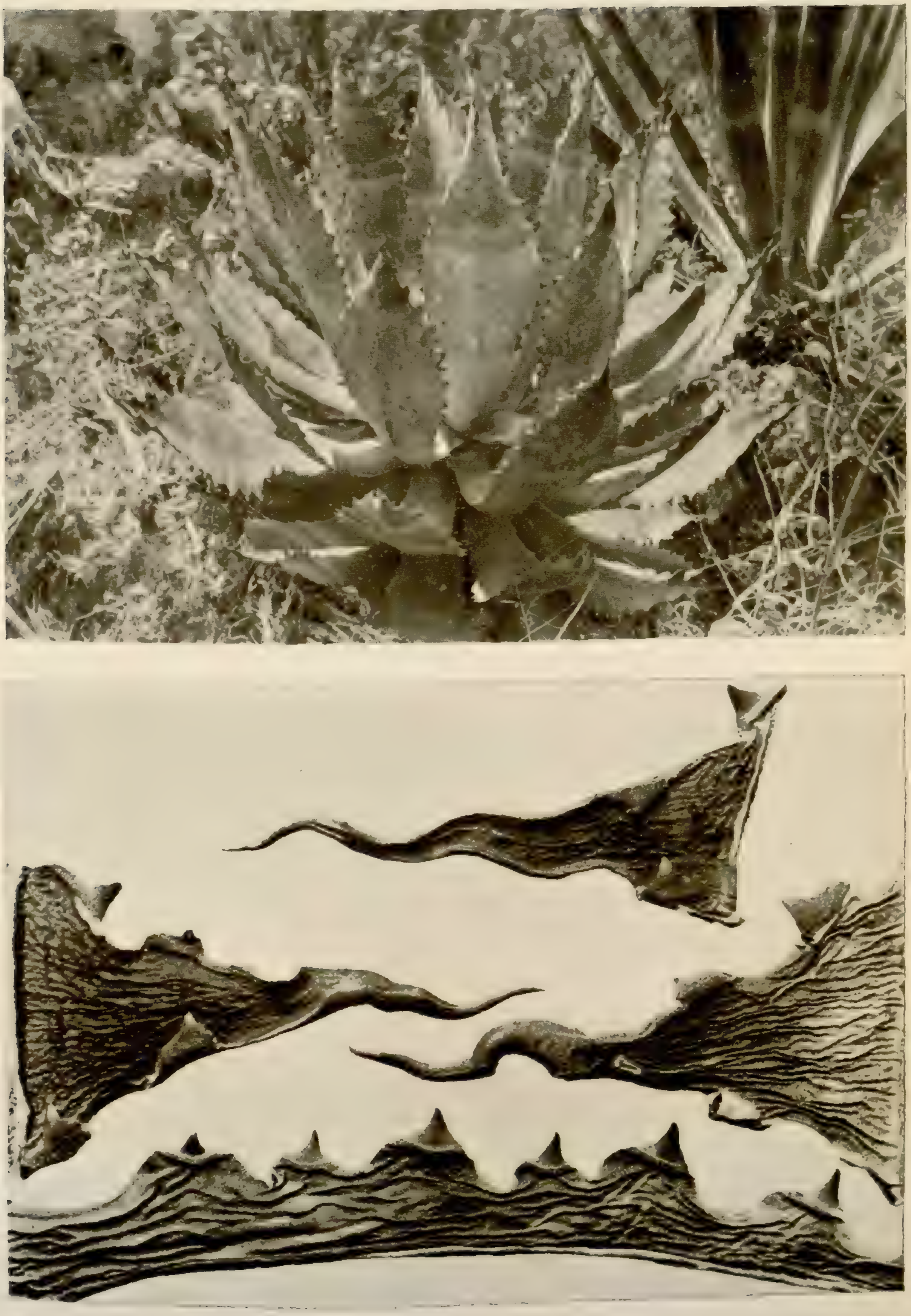
PLATE XXXIII. *Furcraea guatemalensis.* Above, plant growing on a steep hillside, showing the upcurving leaves, Guatemala City. Below, leaf-tips and margin, from the type (*Trelease, 23*), natural size.

Plate XXXIV.—*Furcraea guatemalensis.* Capsules, seeds and bulbils, natural size. Palin, Guatemala (*Trelease, 30*).

Plate XXXV.—*Furcraea melanodonta.* Above, the type group, at Cruz, Guatemala. Below, leaf-tips and margin, from the type (*Trelease, 26*), natural size.

The University of Illinois, June 2, 1915.

Issued July 15, 1915.

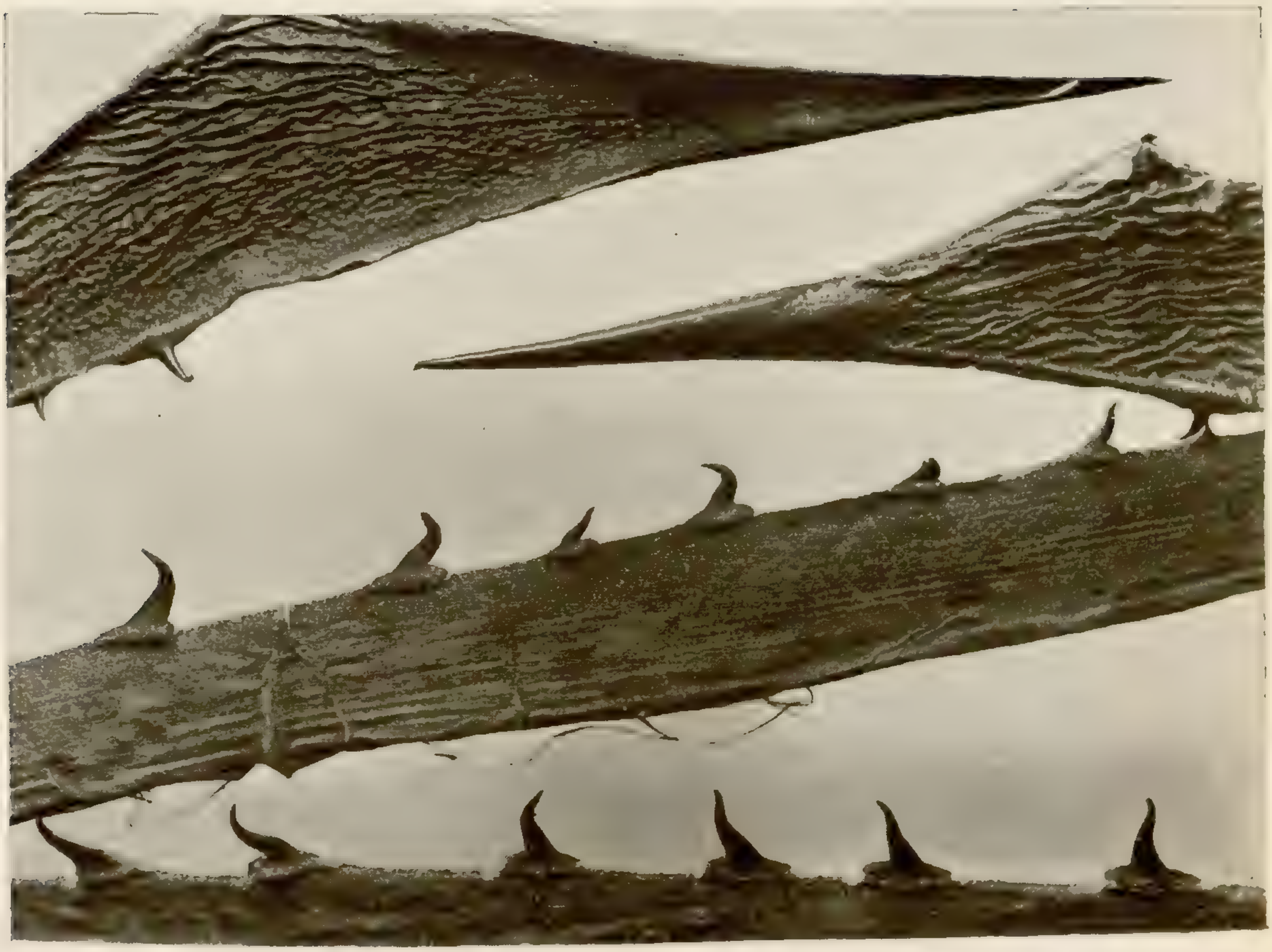


AGAVE TORTISPINA.

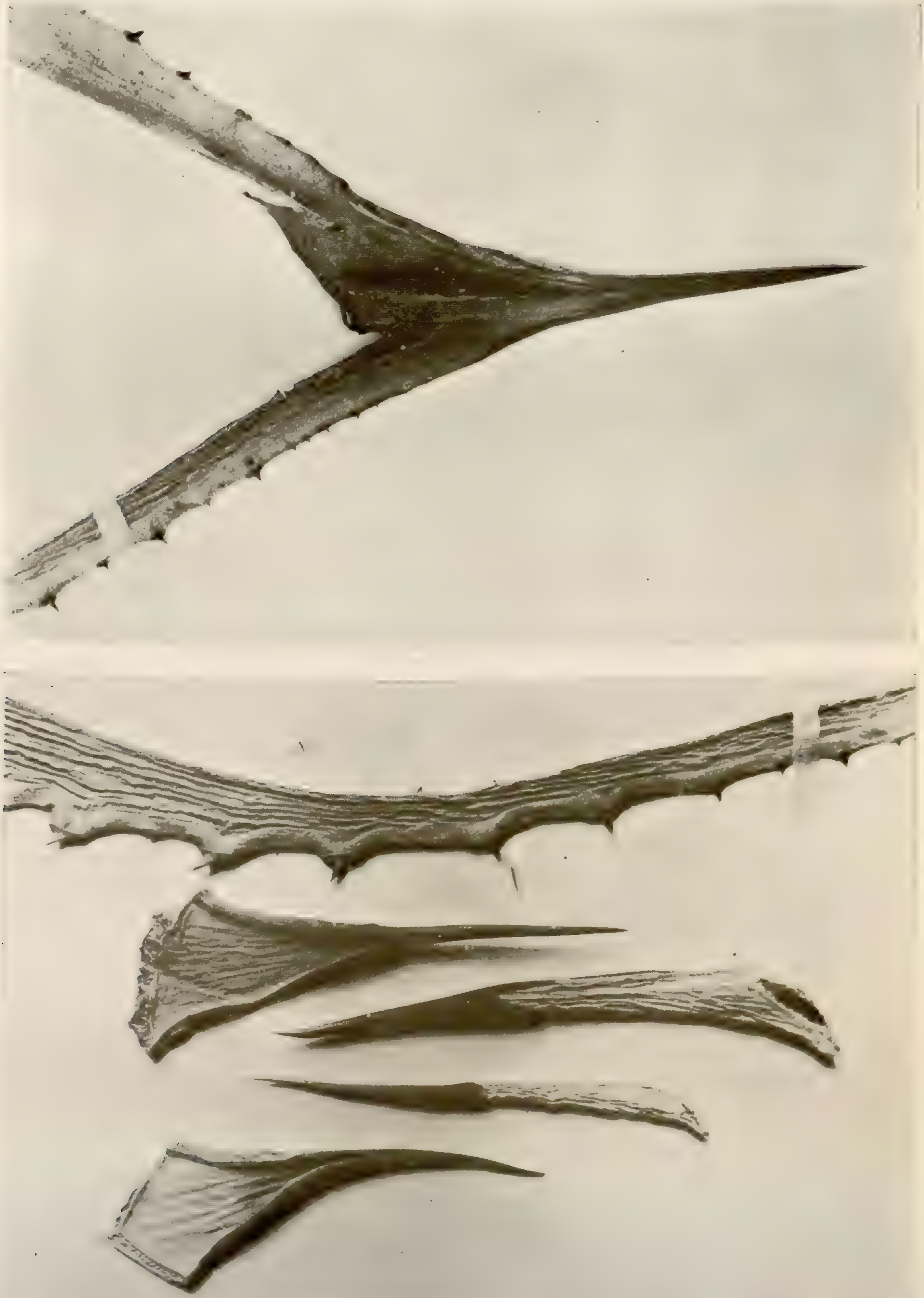
AGAVE PACHYCENTRA

AGAVE HURTERI.

AGAVE HURTERI.



AGAVE HURTERI.



AGAVE SEEMANNIANA.

AGAVE THOMASAE.

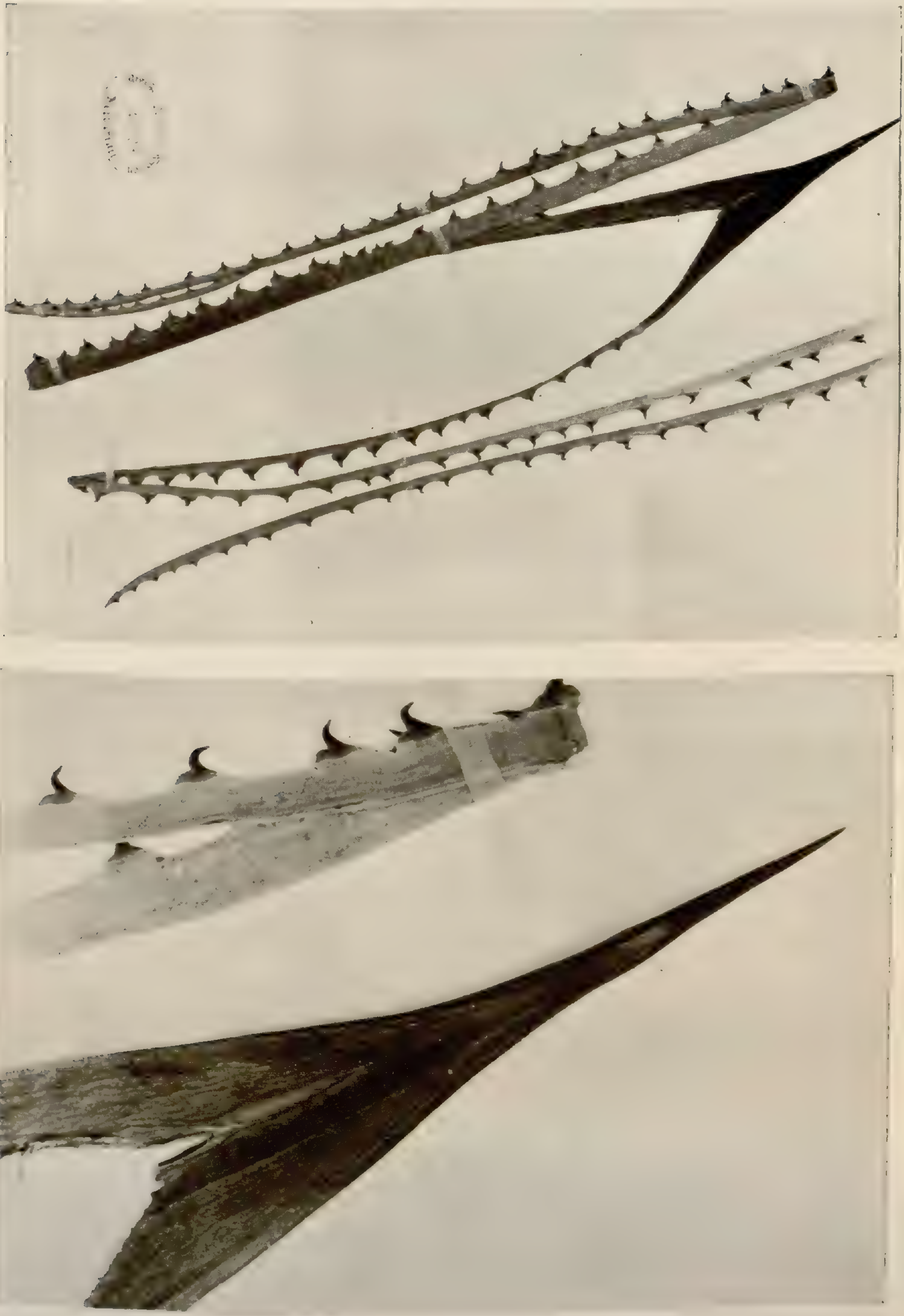
AGAVE DEAMIANA.

AGAVE MINARUM.

AGAVE TENUISPINA.

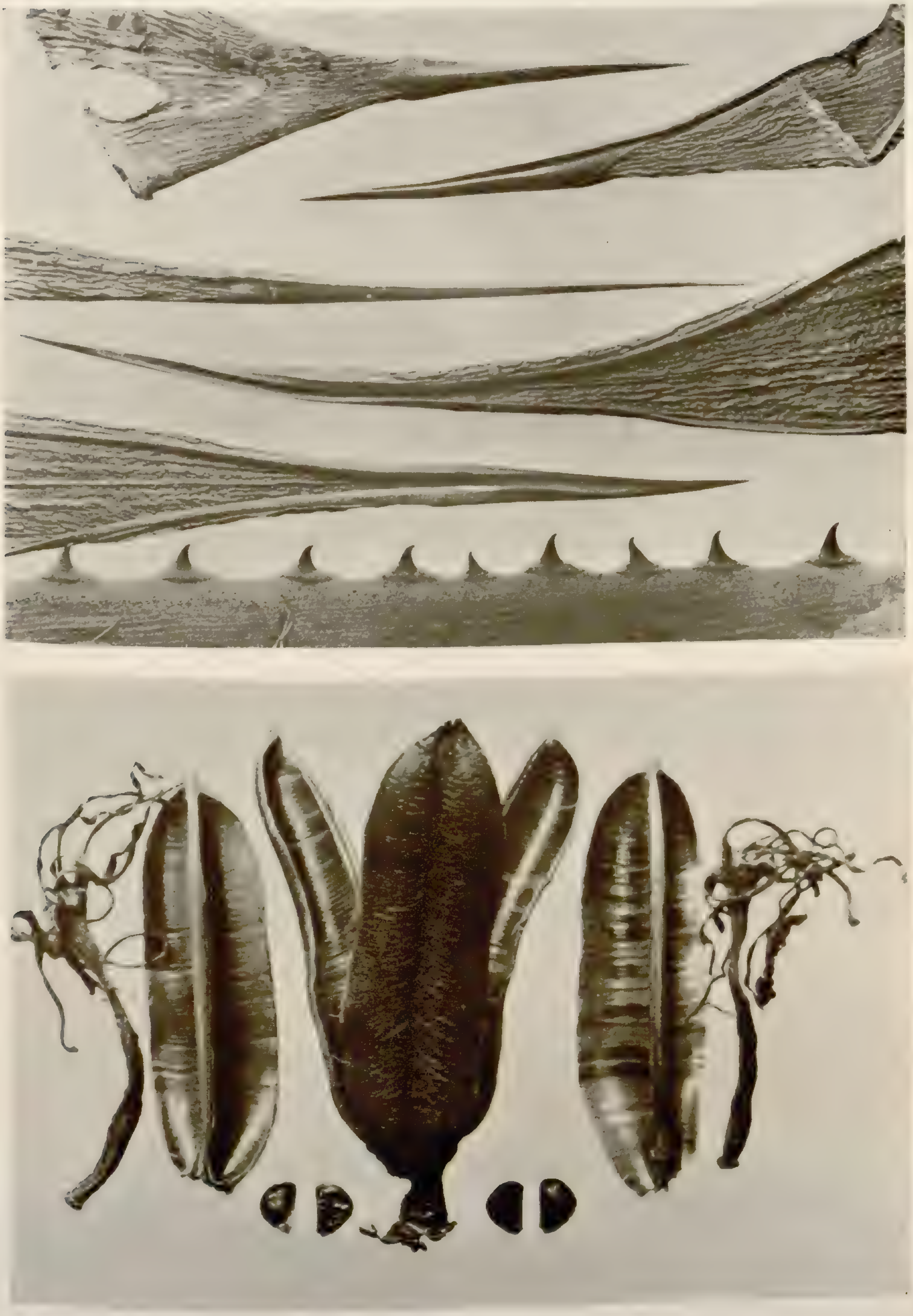
AGAVE OPACIDENS.

AGAVE SICAEFOLIA.

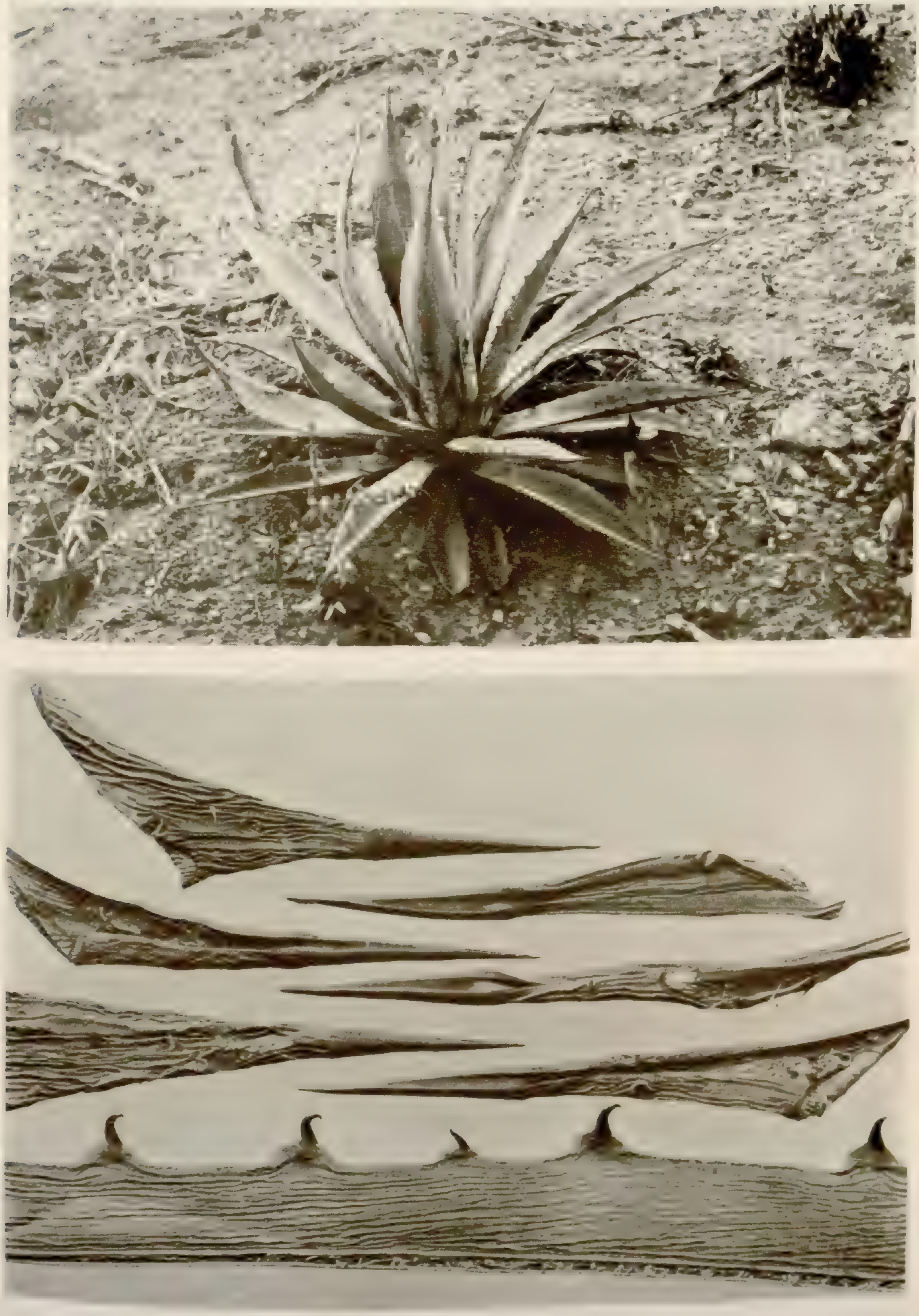


AGAVE KELLERMANIANA.

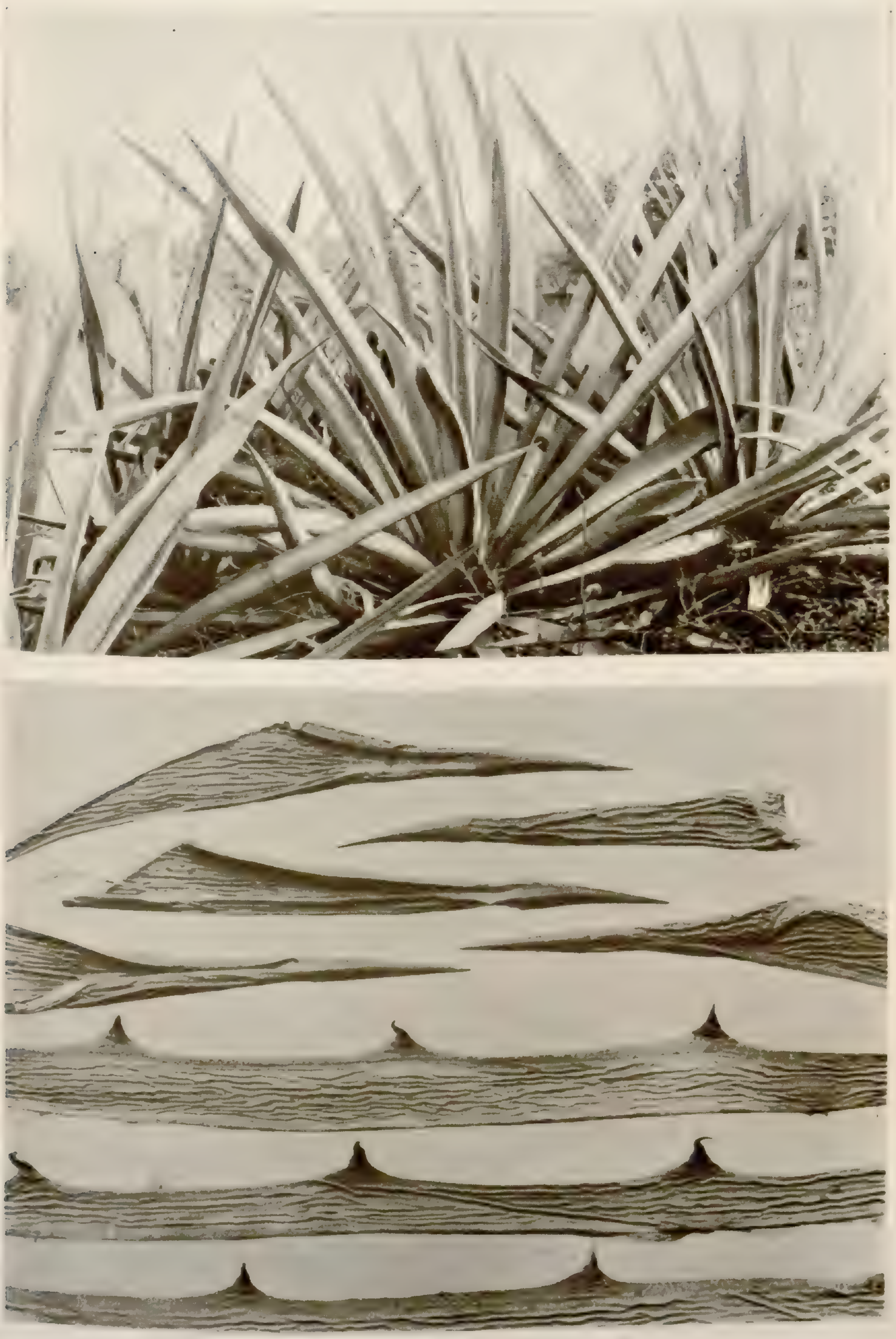
AGAVE SAMALANA.



AGAVE SAMALANA.



AGAVE LAGUNAE.



AGAVE NIVEA.

AGAVE DONNELL-SMITHII.

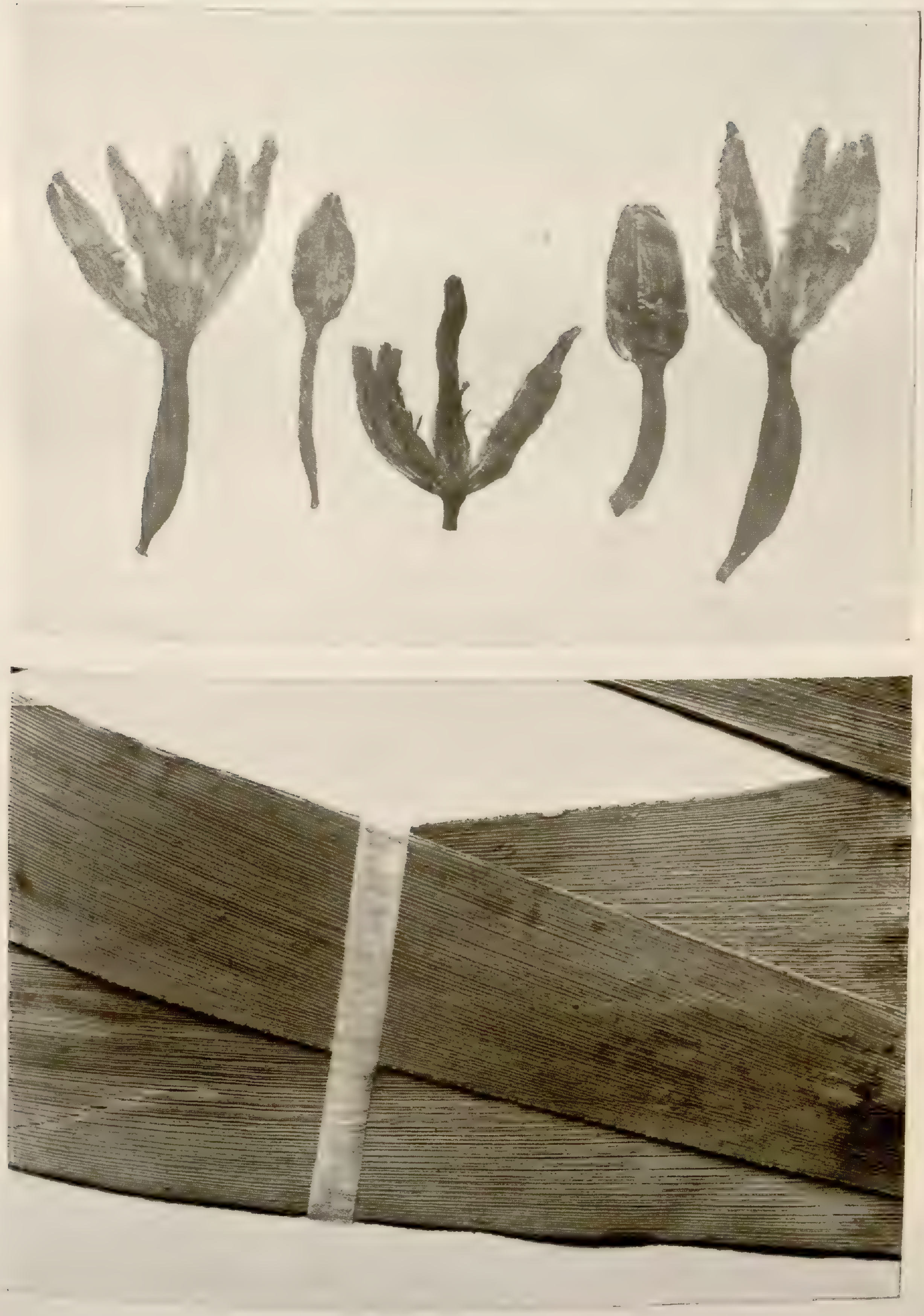
AGAVE DONNELL-SMITHII.

AGAVE DONNELL-SMITHII.

AGAVE TECTA.

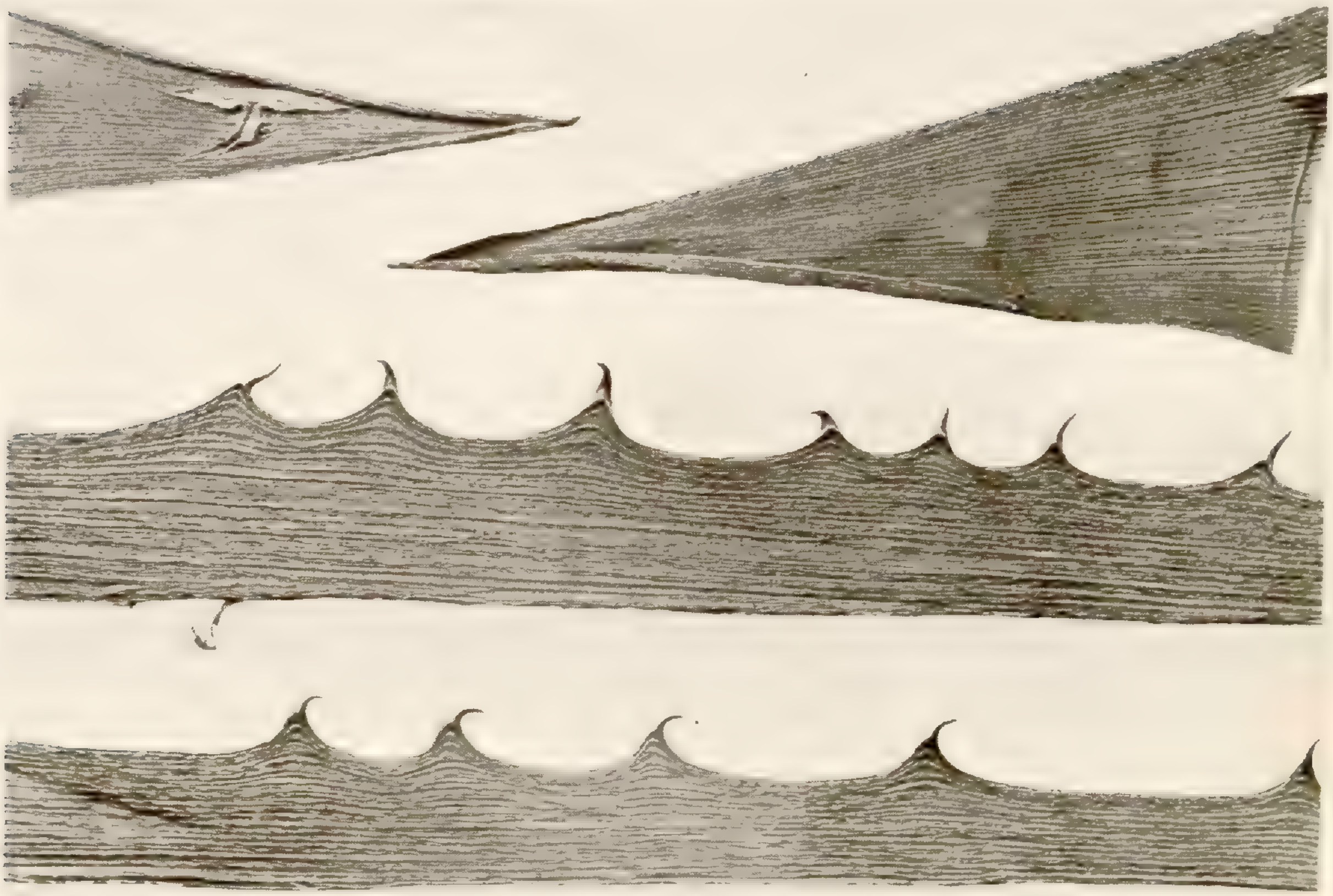
AGAVE TECTA.

FURCRAEA LONGAEVA.



FURCRAEA QUICHEENSIS.

FURCRAEA SAMALANA.

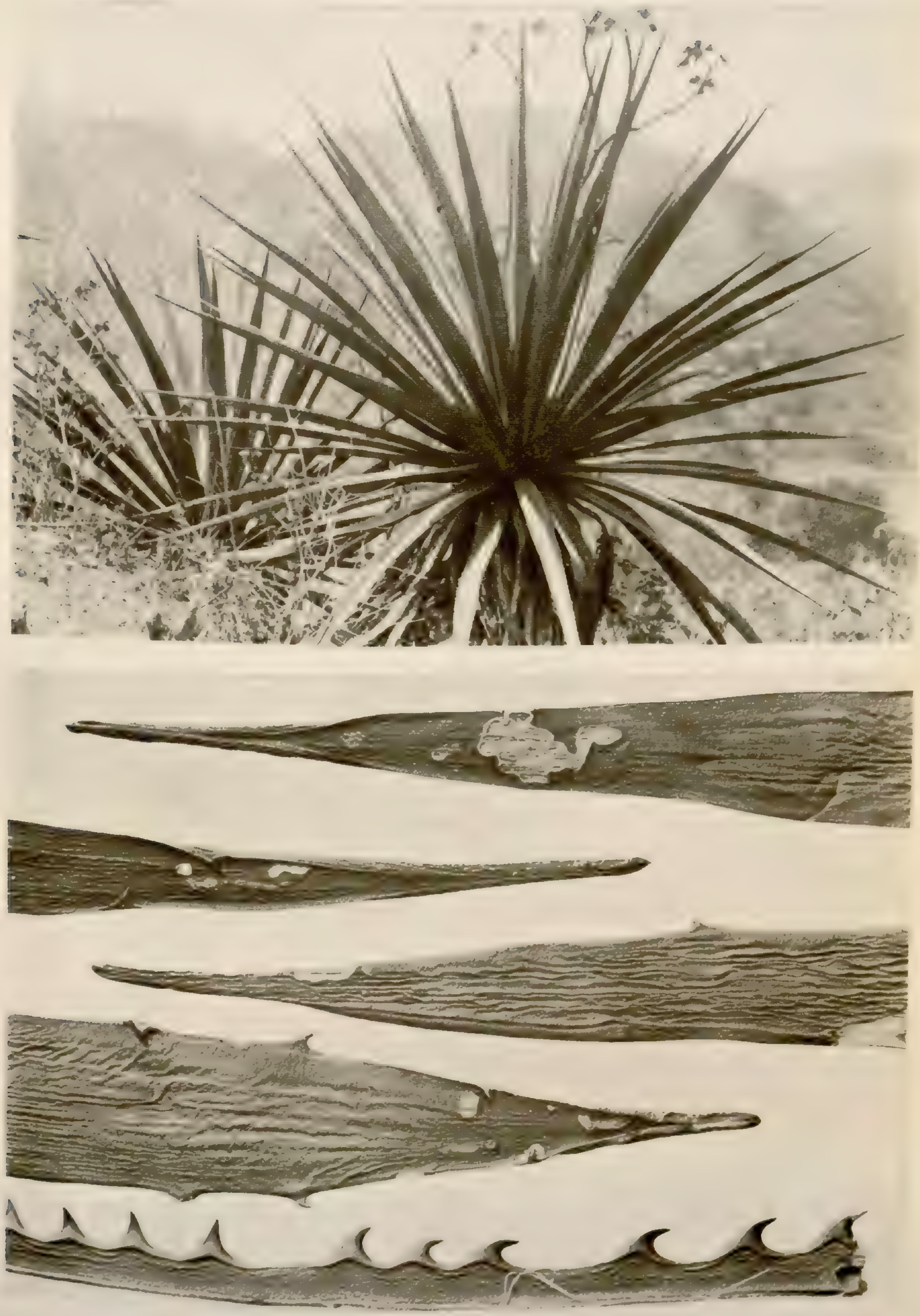


FURCRAEA SAMALANA.

FURCRAEA GUATEMALENSIS.

FURCRAEA GUATEMALENSIS.

FURCRAEA GUATEMALENSIS.



FRUCRAEA MELANODONTA.

Transactions of The Academy of Science of St. Louis.

VOL. XXIII. No. 4.

DISTURBANCES IMPRESSED UPON THE EARTH'S MAGNETIC FIELD.

GRAVITATION AND ELECTRICAL ACTION.

FRANCIS E. NIPHER.

Issued July 28, 1916.

DISTURBANCES IMPRESSED UPON THE EARTH'S MAGNETIC FIELD.*

FRANCIS E. NIPHER.

It is now thirteen years since the writer first made a long series of experiments, in which an attempt was made to reproduce, by means of explosions, the magnetic disturbances due to solar outbursts. These results were finally obtained at my summer home near Hessel, Mackinac County, Mich., during the summer of 1914.

In these experiments, half a ton of rapid burning blasting powder and 300 pounds of 40 per cent dynamite was used. The expense involved was paid by the Carnegie Institution of Washington.

The magnetic needle and its enclosing case was fully described in a former paper.[1] As in the work described in the former paper, all possible precautions were taken to make the case surrounding the needle air-tight. The damping wire dipping into coal-oil in the bottom of the glass bottle which formed the enclosing case, was only 1 cm. in length, in order to give to the needle more freedom of motion than it had in former work. The socket, provided with leveling screws into which the bottle was sealed, was securely clamped to the table. The top of the tube of metal within which the suspension fiber was hung from a torsion head, was braced by four bars of wood, inclined at an angle of 45° with the vertical. Along these bars were four heavy cords, attached to the torsion head, passing down through the table. Upon these cords were

* Presented by title to The Academy of Science of St. Louis, December 6, 1915.

[1] Variations in the Earth's Magnetic Field. Trans. Acad. of Science of St. Louis, XXII:109-110. 1913.

hung two bars of wood, at right angles to each other, each being loaded with about ten pounds of rock. This was done in order to prevent lateral vibrations of the magnetometer case. The arrangement is fairly well shown in Plate XXXVI, Fig. 1. When this view was taken two of the bars bracing the torsion-head had been removed, in order to make the details of the arrangement more clearly visible. The tent had also been removed. The magnets serving to deflect the needle into an east and west position were steel bars, four feet in length and having a cross-section 3/8x1.5 inch. These bar-magnets were enclosed in heavy rubber tubing with plugs closing the ends, and mounted in V-shaped supports within wooden boxes. The boxes were filled with dry and fine grained saw-dust, which was packed closely around the tubes enclosing the magnets. These boxes are shown at the ends of the framed structure forming the table. They were inclined at an angle of 45° with the magnetic meridian. See Fig. 1.

The compensating magnets, which served to reduce the strength of the resulting field thus formed, were of four like bars of steel. On either side of the needle were two bars in reversed position, bound together by strong cords. They were wound with adhesive rubber tape. They were separated from each other by blocks of wood having a thickness of about one cm. They were mounted on edge within the boxes. They thus acted differentially upon the needle. Single bars on either side, when placed anywhere within the available space, would reverse the needle, and give too strong a resultant field. The two boxes, each of which contained such a doublet of such compensating magnets, are shown on either side of the magnetometer in Plate XXXVI, Fig. 1. These boxes were also packed with saw-dust. The four boxes were clamped to the supporting framed structure by heavy wooden clamps. The boxes and frame were loaded with fully half a ton of rocks. An end view of the south end of the table is shown in Plate XXXVI, Fig. 2. The framed struc-

ture rested upon six posts, which were set two feet into the ground. It was held together by means of brass bolts and copper nails. It was so rigid that the impact of the body of a man against it produced no appreciable effect upon the needle.

When ignited in open air, the black powder burned rather slowly. The best results were obtained when 25 or 30 lbs. of the powder, spread uniformly over a platform of 20 square feet, was ignited directly east or west of the needle, and at a distance of a foot from the side of the tent. Boards were placed on end between the tent and the platform in order to protect the tent. The fly above the roof of the tent was moistened by a spray of water. In order to protect the magnets from any possibility of heat effects two curtains, formed of heavy blankets padded with cotton, were hung within the tent. They were so placed that an air-space of five or six inches was between the two curtains. The chair of the observer was inside of the middle of the inner curtain and between the flame and the magnetic needle. There was no explosive effect due to the burning of the powder. It required a time of about 30 seconds for 30 lbs. of powder to burn. The flame shot upward to a height of about 20 feet.

On the day when the results to be given were obtained, there was a very faint wind from the north. The sky was clear. A huge column of smoke drifted slowly upward. It practically coincided in direction with the lines of the earth's magnetic field. The effects produced were of the same order of magnitude as were often observed, due to other and unknown causes.

Plates XXXVIII and XXXIX are fairly representative of the results. The hour of the day is laid off on the horizontal axis. On the original diagram 5 cm. represent one minute of time.

On the vertical axis the reading of the position of the needle is represented, 5 cm. representing 10 scale divisions or 28.4 minutes of arc. The zero reading was at the middle point of the scale.

The strength of the field just outside of the flame, at the point occupied by the needle, was in every case increased by the flame. The commotion of the ionized molecules within the flame, decreased the permeability of the space occupied by the flame. The lines of force were deflected around this vertical column. The instant when the combustion began is represented by the arrow on the two diagrams. The effect upon the needle did not continue in any case for very much more than one minute, and it was generally somewhat less.

The explosions of dynamite in open air produced a disturbance over a very large area. In some cases as many as 22 sticks of 40 per cent dynamite were laid upon a long bar of wood, having a cross section of 1x1.5 inches. Each stick was securely bound to the bar at each end, by means of heavy binding twine. The sticks were placed end on end and the explosive cap was placed in the stick at the end of the column. The bar was mounted upon supporting posts at a height of eight ft. above the ground. No trace of the bar of wood could be found after the explosion, except the shattered ends projecting slightly beyond the column of dynamite. The marsh grass and iris which was about 2 ft. in height was closely shaved from the surface of the ground, over a distance of about 30 ft. on either side of the column. It was all deposited in a long heap directly below the line of the column. Evidently the rebound of the compression wave of air and gas from the ground, had caused an inflow which swept the grass inward and upward. No disturbance of the tent, 275 ft. distant, could be detected. A screen of boards was erected in front of the end of the table to protect the needle, but fine fibers of silk suspended within the tent showed no appreciable deflection. A window glass in our cottage, having dimensions 29x30 inches, was broken by an explosion of 25 sticks. The cottage was distant 225 ft. This does not necessarily mean that the breakage was due wholly to the explosion. A glass which replaced it also broke down a few weeks after being put in place,

although it had not been exposed to any explosion. The effect due to an explosion of 21 sticks, 200 ft. to the north of the needle, is shown in Plate XL. The arrow indicates the instant at which the explosion took place. The intensity of the field was increased at first. The change in position caused the scale reading to change by about 1 cm., the angular change being thus 28.4 minutes of arc. The highest reading was reached about one minute after the explosion. This was followed during the next minute by a decrease in H, to a value less than that just preceding the explosion. At the end of two minutes the value of H had returned to that which it had at the time of the explosion. This disturbance was attended by to and fro vibrations of the needle, which did not exist before the explosion.

On the same day, shortly after 11 a. m., when the needle had been indicating for half an hour a steady rise in the value of H, an explosion of 20 sticks was followed by a series of vibrations which continued for twelve minutes. The amplitude increased for four minutes, and the vibrations gradually ceased at the end of twelve minutes. The maximum angle of oscillation, four minutes after the explosion, was 114 minutes of arc, or forty scale divisions. The mean reading for each oscillation showed a rise in the value of H, during the first four minutes, the average reading changing by twenty scale divisions. When the vibrations ceased the reading differed from that at the time of the explosion by four scale divisions, the field being slightly weaker.

When ten sticks of dynamite were exploded there was no appreciable effect upon the needle. It did not exceed two scale divisions. When six sticks were exploded, the needle having been very quiet, the needle continued to move uniformly, and without oscillations. The field was, however, made weaker. Two minutes after the explosion, the change in reading was eight scale divisions. The field then began to increase in strength, and five minutes after the explosion it had regained the value which it

had just prior to the explosion. When three sticks were exploded the decrease in the intensity of the field was still more marked. The needle was vibrating slightly before the explosion. The amplitude increased from two or three scale divisions to twenty-five. The decrease in the intensity of the field was represented by a change in the average reading of twelve scale divisions.

It seems probable that the lines of force of the earth's field are deflected around the space which is filled with the gases liberated in the explosion, and that in the space immediately adjoining, the field is thereby made stronger, although the commotion of the air there also tends to make the field weaker. The action is a differential one. At greater distances the main effect is due to the agitation of the air, and here the field is made weaker. There must be an intermediate position where these two influences balance each other. The distance of this position will depend upon the magnitude or violence of the explosion.

In some of the preliminary work fifty sticks were mounted in the air upon a raft of logs, which was anchored in the lake to the south of the station. Its distance from the observing station was about three thousand feet. The effect of this explosion upon the needle was inappreciable. It was at that time a very surprising result. It now seems to be apparent, that an effect would have been observed if the distance had been somewhat less, or very much greater.

Another source of disturbance of the magnetic field was examined during the summer. The captains in command of the steamers plying between Mackinac Island and Les Cheneaux Islands, were directed by Mr. Geo. T. Arnold, president, to blow a long and loud blast on the fog-horn, when at a point nearest to the station. There were three opportunities on each day to make such observation. Plate XXXVII, Fig. 1, shows the location of the steamer while the horn was in operation. This view was taken from the roof of the porch in front of the

cottage. The observing station was a few rods to the left of the view here shown. The path shown in the foreground turns to the left past the station.

Observations were made upon the effect of the fog-horn during the entire summer. It soon became evident that no effect could be expected upon days when the sky was covered with clouds. The most marked effects were observed in the afternoon on clear days and when the air was quiet.

The blast of the fog-horn was sometimes followed by vibrations of the needle. Such a result is shown in Plate XLII. Such vibrations occur which are due to other causes, and it may well be that the air disturbance due to the blast of the horn is the final agency, which, superposed upon other causes, brings about rhythmical variations in the earth's field.

The usual effect upon the needle was a slow deviation in a direction indicating a decrease in the intensity of the field. In no case was the blast of the horn followed by an apparent increase in the intensity. Plate XLI gives a fair representation of the effect usually observed. Here the drop from 11.1 to 10.8 cm. in the reading during a two-minute interval indicates a change of 3x2.84 minutes of arc in the position of the needle. On two occasions the sunset disturbance followed at once. On Aug. 25 these oscillations, which represent this disturbance, began about an hour before the time when they were usually observed to begin. They are represented in Plate XLIII.

The period of oscillation was nearly uniform and the scale reading was taken at the extreme of each oscillation. If this diagram were plotted to the same scale as those which precede, these oscillations would have five times the amplitude shown in this diagram. At this time the sky was clear, and there was no appreciable wind.

The effect of dynamite explosions at a great distance from the explosions may be expected to resemble that due to the fog-horn.

These results have been repeated in the laboratory at St. Louis during the spring of 1915. Deflecting magnets which were balanced against each other on a needle which was rendered sensitive by compensating magnets were used, as in former experiments. One of the deflecting magnets was much feebler than the other, so that it was nearer to the needle than the other. The air around the smaller magnet was electrified. A musical note from an organ pipe produced effects which were superposed upon other disturbances of similar magnitude. The effect of the musical note was appreciable, although at times the other disturbances interfered with the result. The blast of air from a compression tank, by means of which the organ pipe was operated, produced more marked results. The blast of air from a rubber tube was directed through the space between the smaller deflecting magnet and the metal shield around the needle.

During the summer of 1914 an attempt was made to examine the magnetic field around a column of exploding dynamite. The effect sought was an Ampère effect due to a special form of Rowland's convection current. A half stick of dynamite was crumbled into fine powder, and packed into the angle of a wooden trough made from bars of wood. The explosive cap was placed at the end of the column. The trough was placed in the position shown in Plate XXXVII, Fig. 2. It was in line with the needle and eight inches above the level of the needle. The inner end of the trough was about ten inches from the tent and about 7 feet from the needle. Great difficulty was found in making the entire column explode. In two cases a complete explosion of the column, having a length of 15 ft. occurred. In these cases the wood of which the trough was made was of very inferior quality and the entire trough was shattered into small splinters which were scattered over a distance of 30 ft. In these two cases the cap was placed at opposite ends of the column. The needle was deflected in opposite directions in the two cases. The deflection was such as would be caused by

negative electrons moving in the same direction as the explosion. In other cases the explosion was not complete. In many cases not more than six or eight inches of the column would explode, and the results were conflicting. In the two cases above referred to the deflection was in one case 51 minutes of arc and in the other 54.

It was found that vibrations of the trough, or breaking of the bars into long and large fragments which were not detached from it resulted in disrupting the column of dynamite. It was found that large rocks hung from the trough had a tendency to keep it in stable position and prevented the vibrations.

It has since been found that when the dynamite is slowly poured into a long rubber tube, which is gently tapped in order to make the column continuous, the explosion can be made complete. The tube must be hung in a vertical position while being filled. This work on the convection current is in an unfinished condition.

EXPLANATION OF ILLUSTRATION.

Plate XXXVI; Figs. 1 and 2. Table for magnetic observations.
Plate XXXVII; Fig. 1. Steamer. Blast of Fog-horn.
Plate XXXVII; Fig. 2. Wooden trough containing column of dynamite.
Plate XXXVIII. Magnetic effect of a flame.
Plate XXXIX. Magnetic effect of a flame.
Plate XL. Magnetic effect of an explosion.
Plate XLI. Magnetic effect of sound-waves.
Plate XLII. Magnetic effect of sound-waves.
Plate XLIII. Magnetic effect of sound-waves.

Issued July 28, 1916.

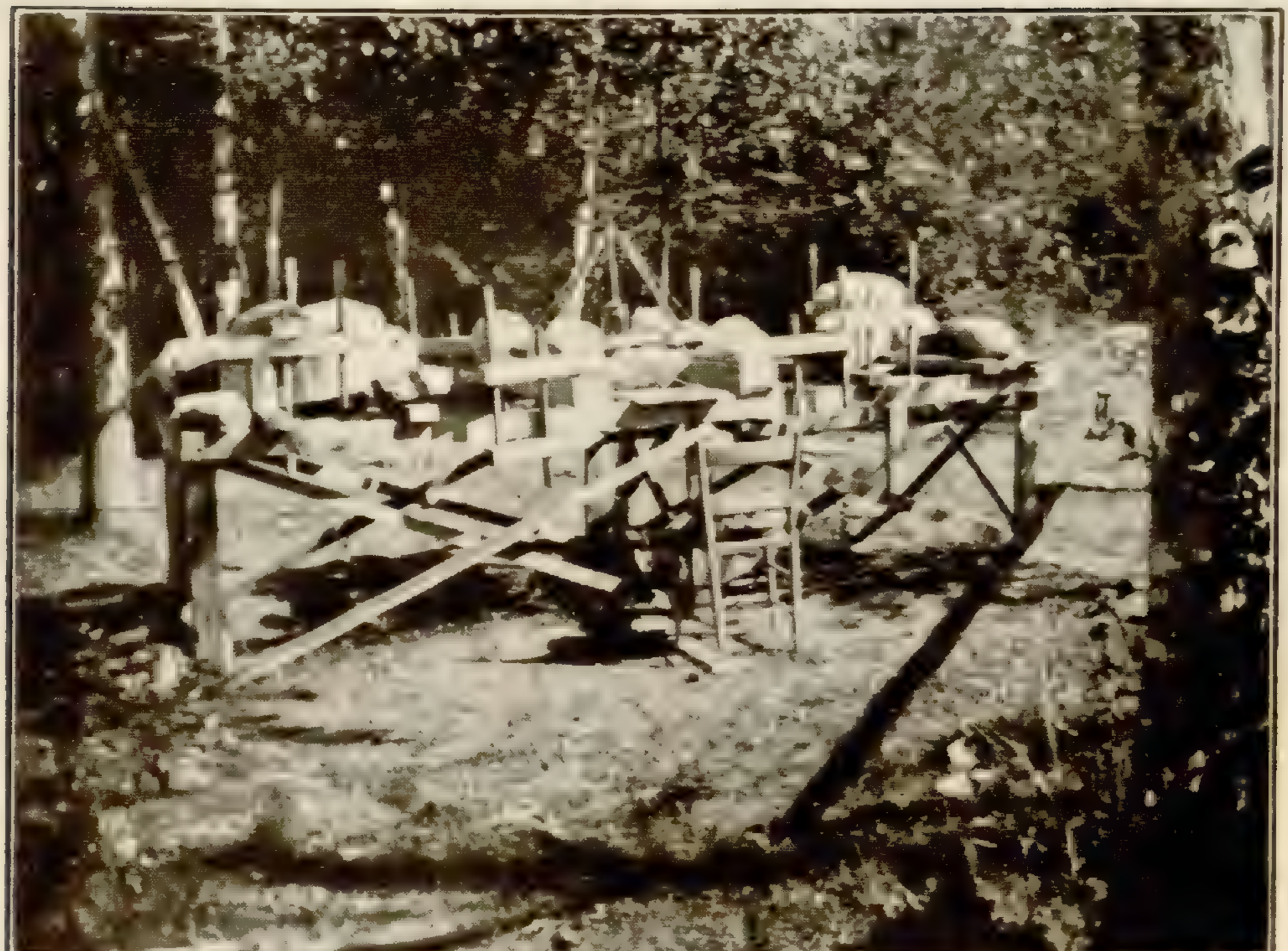


FIG. 1.

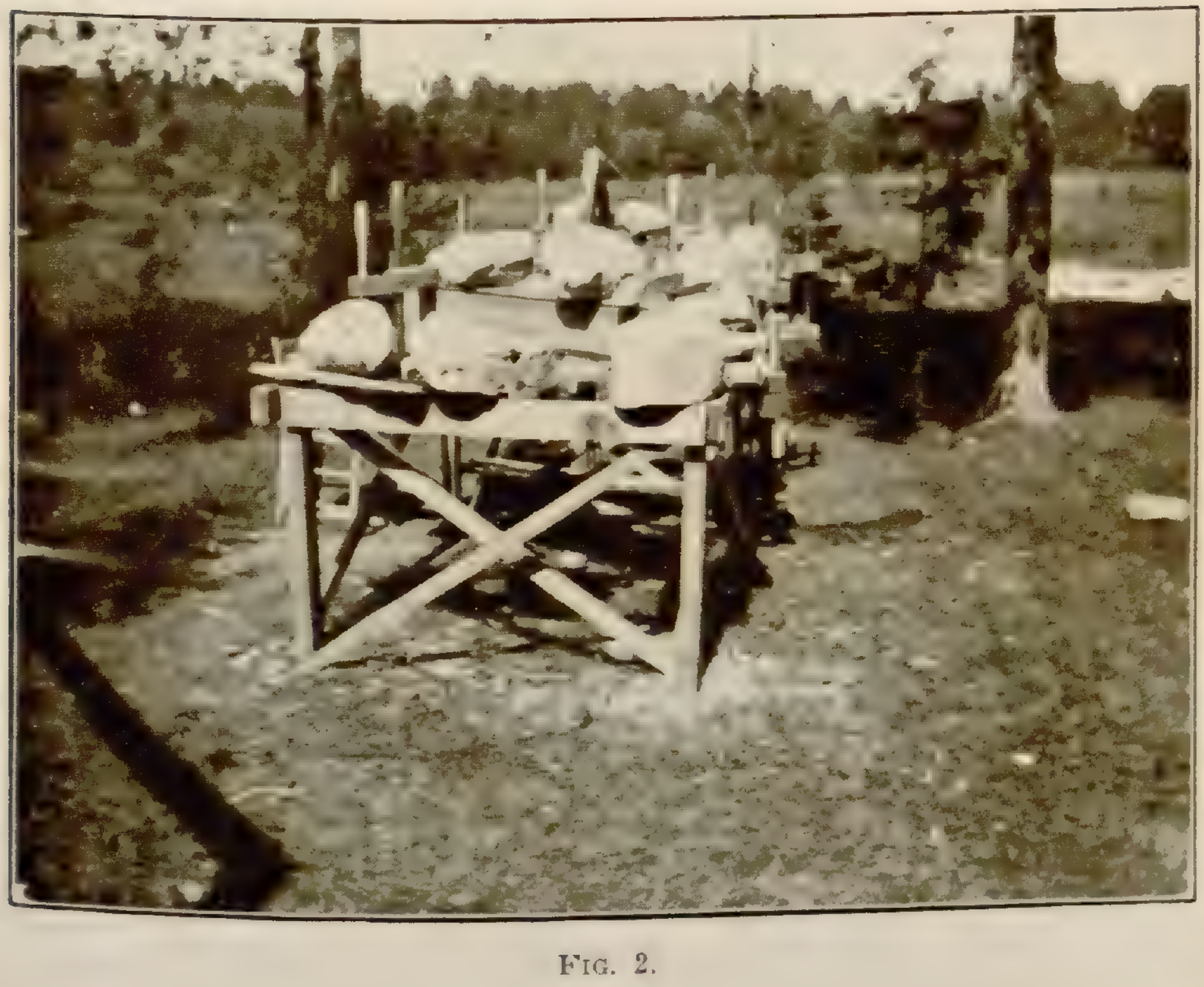


FIG. 2.

FIG. 1.

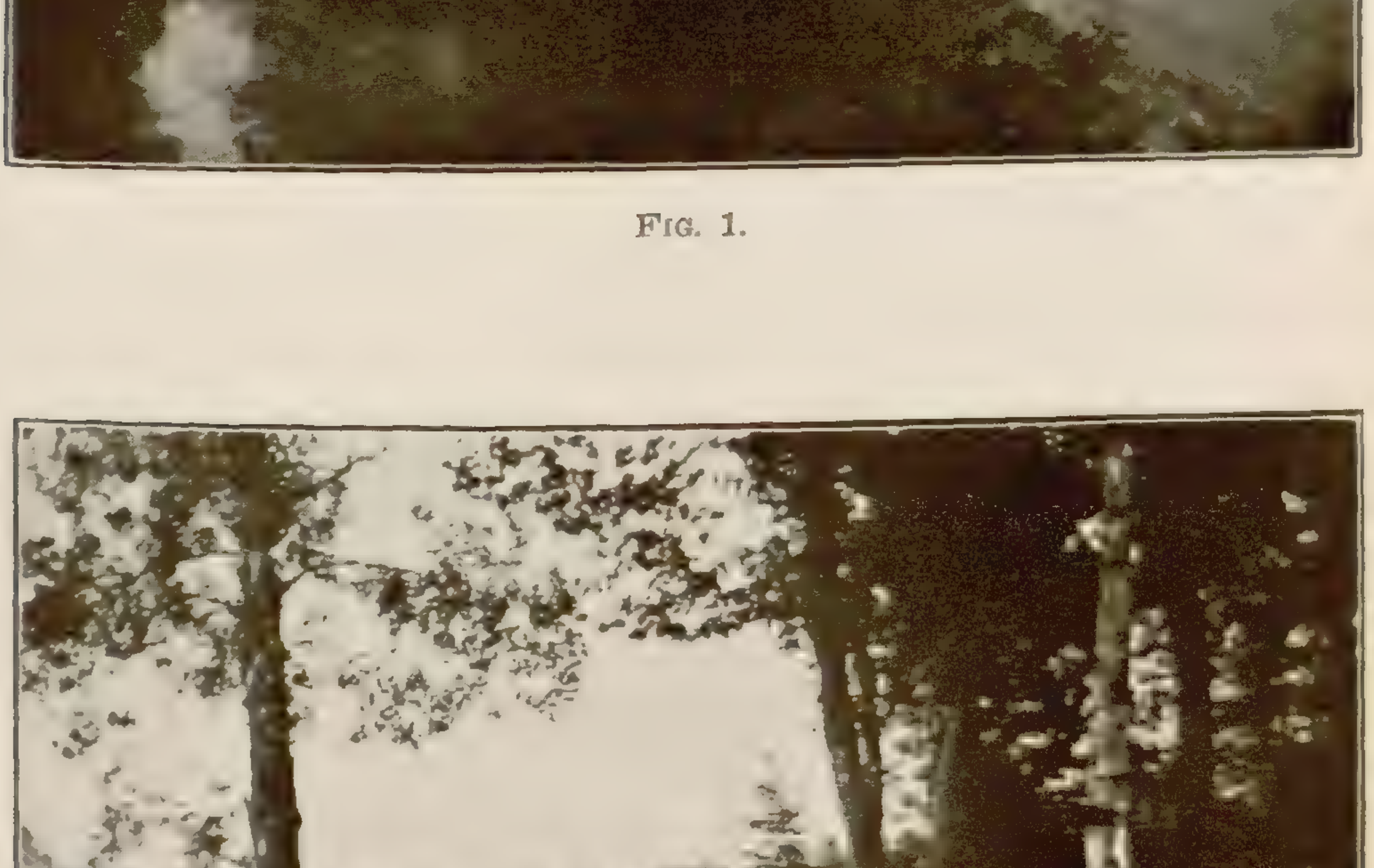
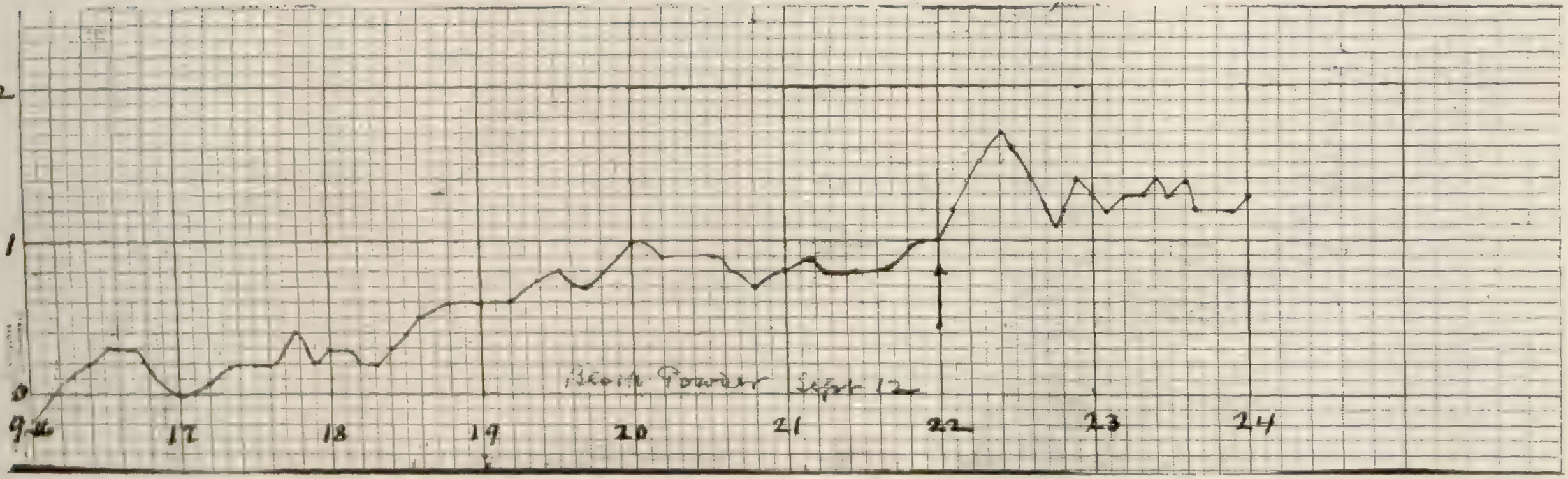
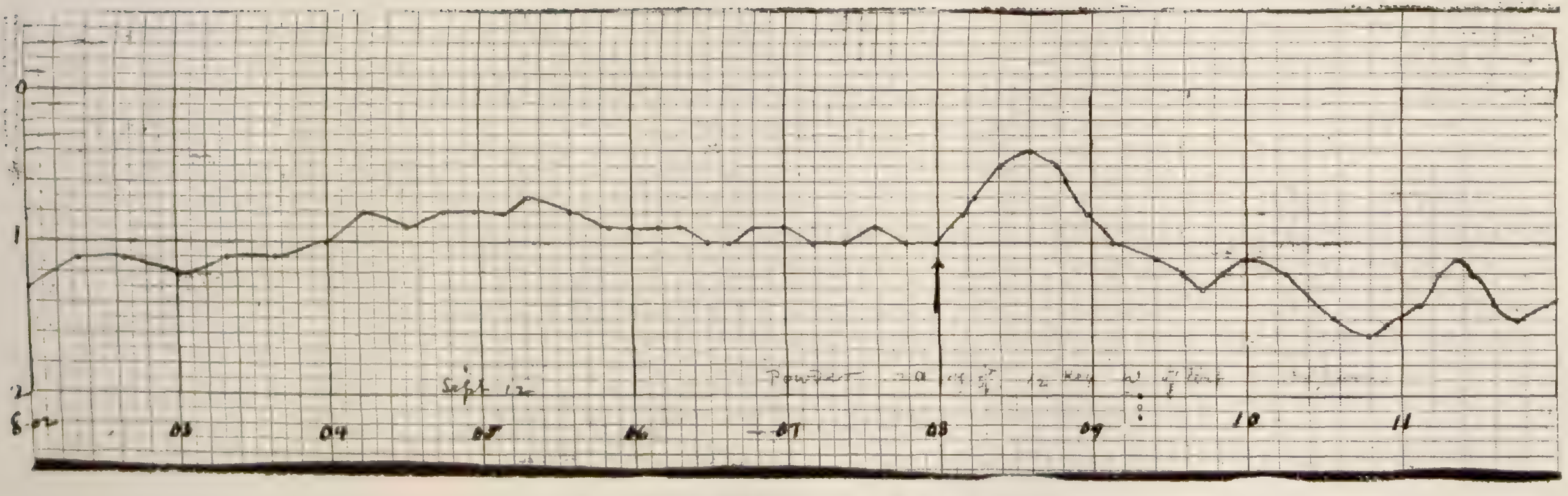


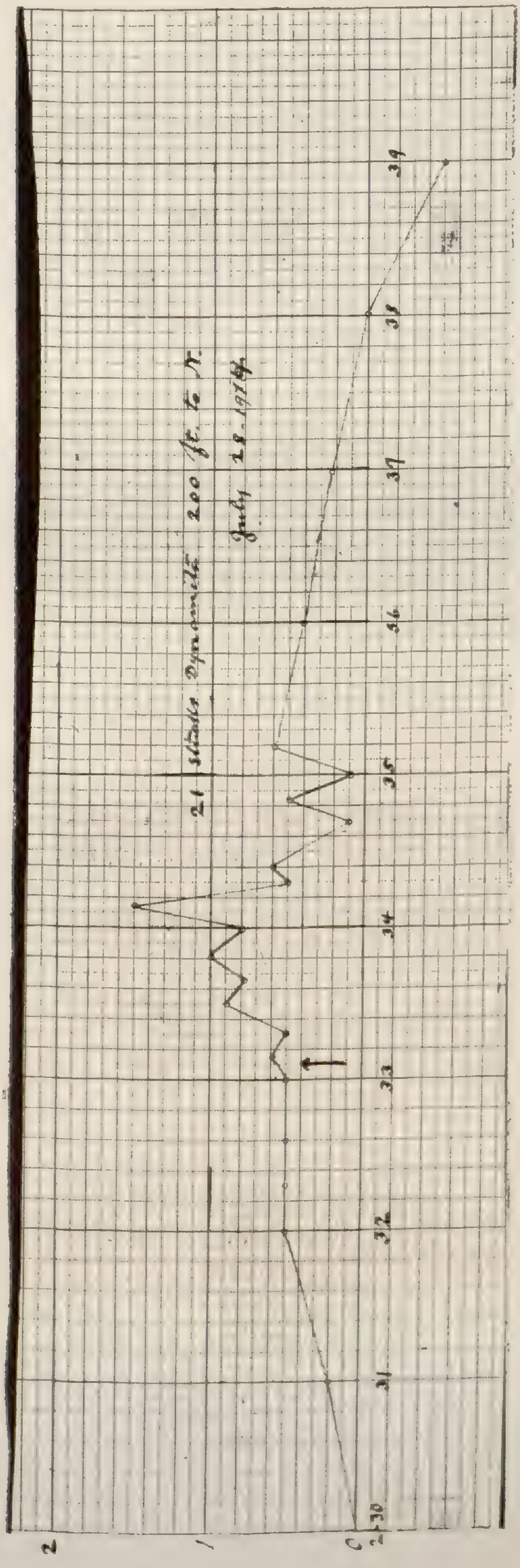
FIG. 2.



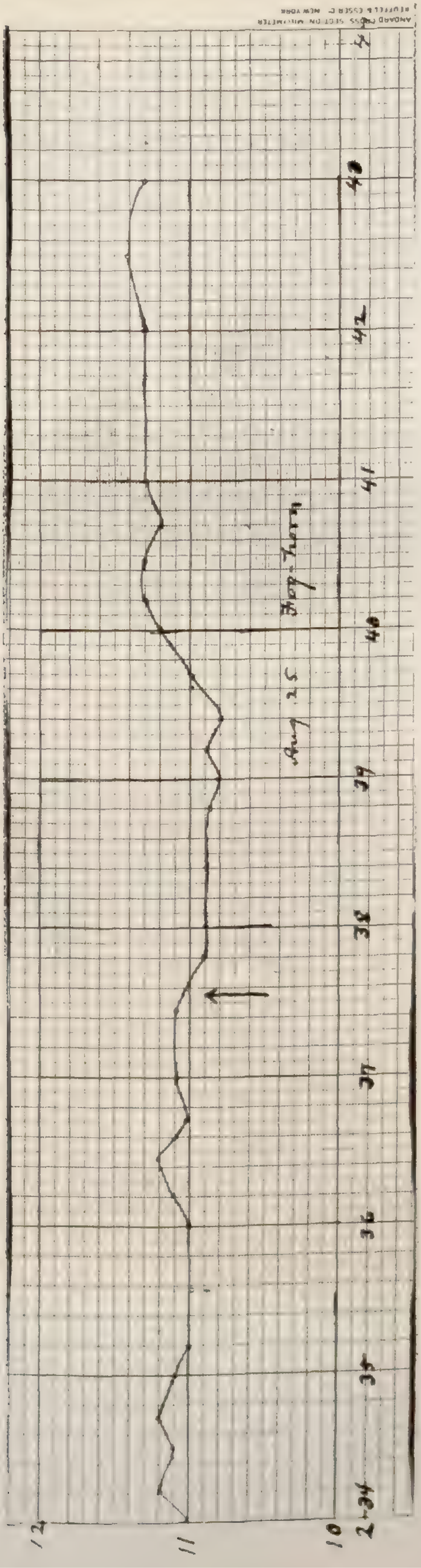
MAGNETIC EFFECT OF A FLAME.



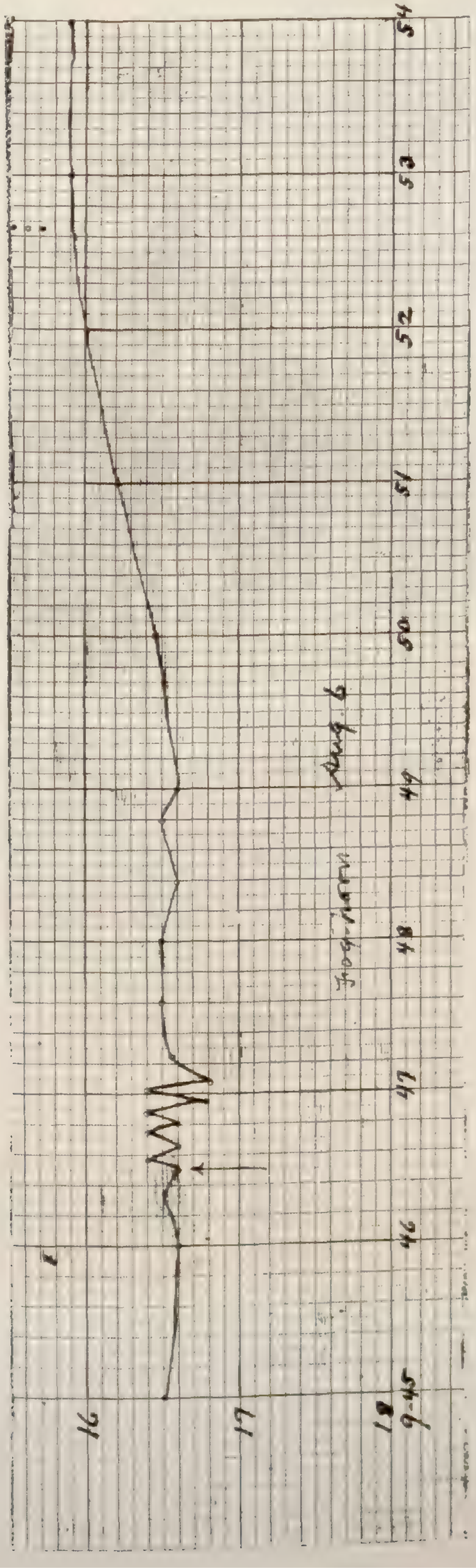
MAGNETIC EFFECT OF A FLAME.



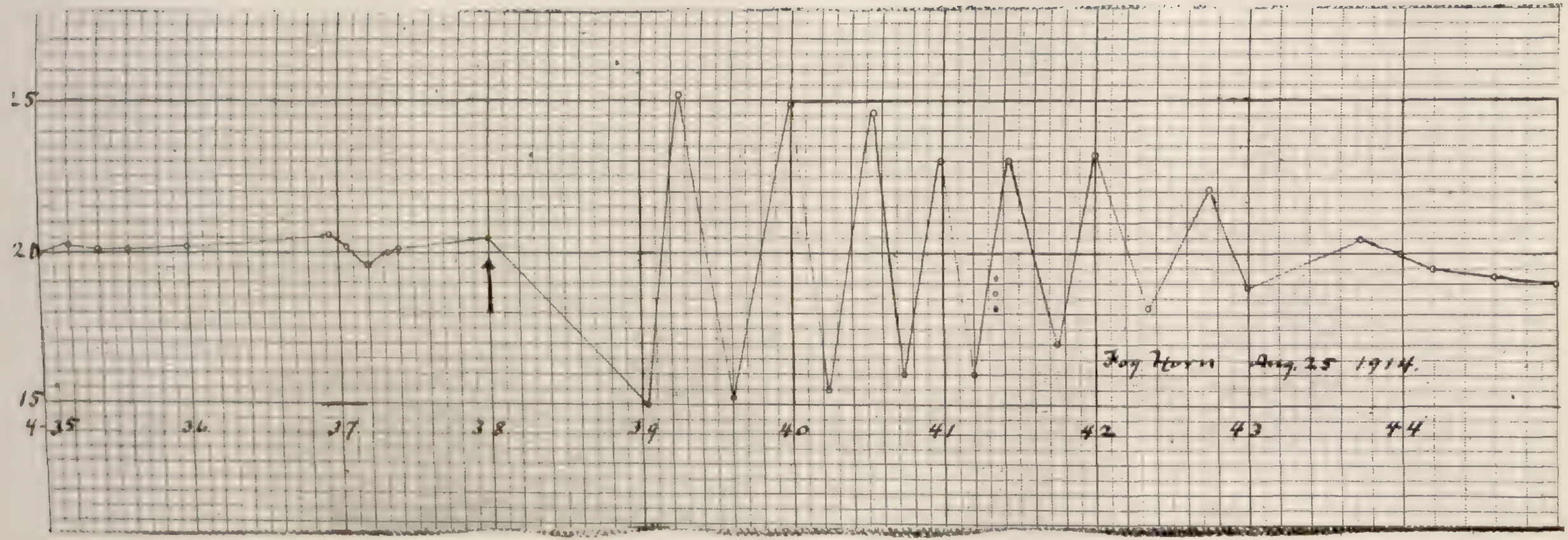
MAGNETIC EFFECT OF AN EXPLOSION.



MAGNETIC EFFECT OF SOUND WAVES.



MAGNETIC EFFECT OF SOUND WAVES.



MAGNETIC EFFECT OF SOUND WAVES.

GRAVITATION AND ELECTRICAL ACTION.*

FRANCIS E. NIPHER.

In former publications the present writer has suggested an intimate relation between gravitation and electrical action.[1]

There can be no doubt of the truth of the statement, that the attraction between any two masses of matter, depends not only upon the amount of matter in the two masses, and their distance from each other, but also upon their electrical condition.

Assume that two spheres, having radii R_1 and R_2, composed of metal having a density ρ, and distant from each other r, have electrical charges Q_1 and Q_2, the spheres having a common potential V. Their attraction for each other will be:

$$A = K \frac{m_1 m_2}{r^2} - \frac{Q_1 Q_2}{r^2}$$

$$= K \frac{16}{9} \frac{\pi^2 R^3{}_1 R^3{}_2 \rho^2}{r^2} - \frac{R_1 R_2}{\mathrm{r}^2} V^2$$

$$= K \frac{16}{9} \frac{\pi^2 R^3{}_1 R^3{}_2 \rho^2}{r^2} - \left(\frac{9 m_1 m_2}{16 \pi^2 \rho^2}\right)^{1/3} \frac{V^2}{r^2} \quad (1)$$

Here K is the Newton constant of gravitation as it would be determined if electrical action were eliminated, or if V were zero absolute. The absolute zero in V

---

* Presented by title to The Academy of Science of St. Louis, February 21, 1916.

---

[1] Proc. Am. Phil. Soc. Philadelphia 52: 283—6.
Science Sept. 1, 1911: 282-3.
Experimental Studies in Electricity and Magnetism. 19-24.

would be the common potential of the two bodies, under the conditions assumed in Eq. (1), when their attraction for each other is a maximum.

The gravitation constant has been determined by methods, which it was assumed made it unnecessary to consider the electrical condition of the two bodies. Nevertheless the results have been very unsatisfactory. In his presidential address before the American Mathematical Society in December, 1899, R. S. Woodward referred to this constant as being one of the constants of the solar system whose determination was in a most unsatisfactory condition, as regards precision.[2]

If the masses are capable of acting upon each other electrically, and the final term in Eq. (1) is omitted, that equation might be written.

$$A = K\left(1 - \frac{x}{100}\right)\frac{16}{9}\ \frac{\pi^2 R^3{}_1 R^3{}_2 \rho^2}{r^2} \qquad (2)$$

In this equation an error of x per cent. in the value of K would result. By (1) and (2).

$$V = \frac{4}{3}\pi R_1 R_2 \rho\ \frac{\sqrt{K x}}{10}$$

If V is measured in volts,

$$V = 40\,\pi R_1 R_2\ \rho\ \sqrt{Kx} \qquad (3)$$

For purposes of illustration assume that K=6.6576$\times 10^{-8}$ and that $R_1 = 10_1$, R_2=1 and $\rho = 11.35$; then

$$V = 3.68\ \sqrt{x}$$

If the common potential of the two spheres differs from absolute zero by 3.68 volts, the value of K would be in error by one per cent of the above value, which is that of Boys, unless adequate means are taken to eliminate the effects represented by the final term of Eq. (1).

If V were $\pm$ 8.23 volts an error of five per cent would result. If V were $\pm$ 36.8 volts, the two spheres would

---

[2] Bulletin Am. Math. Soc. II 6:153.

have no attraction for each other, although both would be attracted by the earth, even if it had the same potential. The attraction of the earth for a gram of lead would then be by (1)

$$A = 981 - 0.000,000,000,006.$$

The acceleration of a falling body would be practically unchanged, and would not depend upon the density of the matter of which it is composed, as it would apparently be under the conditions assumed in Eq. (1).

Raindrops falling through an overcharged[3] thundercloud would repel each other. After the diverging branches of a flash of lightning have penetrated the cloud a new condition has arisen. Overcharged drops of water along the lines of the intricate system of branches of the discharge, have delivered their overcharge to the cloud at the other end of the long flash. These drops are intimately commingled with drops which are outside of the drainage lines. The value of V for these two groups of drops now have opposite signs. The final term in equation (1) then becomes positive, as applied to these groups, and it is much greater than the gravitation term. These drops coalesce as they fall to earth and a brief dash of unusually large drops of rain follows.[4]

In former papers above referred to, an experimental study of explosive effects due to a discharge from a large condenser through a small lead wire was discussed. The wire was sealed within a glass tube filled with coal oil. This work has been continued in a modified form. Four quarter ampère fuse-wires of lead were placed in multiple across a gap, five centimeters in length in a line leading from either terminal of an influence machine to a

---

[3] The word overcharged, or super-charged, was in common use more than a century ago, when the one-fluid theory was in general favor.

[4] See Nipher. A Flash of Lightning. Popular Science Monthly. Jan., 1912: 76.

Nipher. Experimental Studies in Electricity and Magnetism. Pp. 16-17.

water-pipe system. The other terminal was grounded on a gas pipe. The lead wires were clamped between the leaves of two small brass door-hinges, one leaf of each hinge being soldered to one of the ends of the rods at the gap. Between the gap in which the leaves were mounted and the ground was placed a large battery jar filled with four litres of a solution of common salt. The wire was parted at this point, and the ends were immersed in this solution which thus formed part of the ground circuit. One of the wires penetrated the liquid to a depth of about half a cm. Between the gap in which the wires were mounted and the machine was a spark gap, between knobs of equal radius. The condenser consisted of forty large sheets of glass (36x36 inches) having upon them 2x40 square feet of tinfoil. The machine was driven by a single-phase electric motor. Below the lead wires a sheet of white paper was laid upon a plate of glass.

It was found that there was a marked difference between the effect of the positive and the negative discharges upon the lead wire. The resistance of the gap in the salt solution could be so adjusted, that the negative discharge, or the compression wave, would cause the lead wire to fuse and drop in hot globules upon the paper below. The effect upon the paper is shown in Plate XLIV, Fig. 1.

With the same adjustment, the positive discharge causes the lead wires to rise in a cloud of dust. If the paper were placed 3 cm. below the wires, it would usually be practically unaffected when the positive discharge was used. In a few cases, as in Fig. 2, it was slightly discolored by the lead fumes.

Of course the discharge could be made greater, so that either discharge would cause the lead to be dissipated in a cloud. It could be made less, so that fused metal would fall upon the paper when the positive terminal was connected with the ground line containing the wire. In all cases the cloud effect was the more marked in case of the

positive discharge, and the fused metal falling upon the paper was less marked.

In case of the positive discharge there is of course a heat effect. Part of the result is due to this cause. But if we are to consider the positive terminal as an exhaust terminal, into which the negative electrons are suddenly drained and thence into the positive sheets of the condenser, we may explain the result as an explosive condition which is suddenly impressed upon the lead. When deprived of negative corpuscles, each atom repels every other. The negative term in equation (1) has become very much greater than the positive, when applied to inter-atomic attraction under these conditions.

The negative discharge, which is to be regarded as a compression wave could not give a super-charge to atoms within the wire, causing them to repel each other. The super-charge is on the outside of the wire. The one-fluid theory seems to furnish a more rational explanation of these phenomena than the two-fluid theory, as is the case in the phenomena of the Crookes tube.

Some work has been done in the examination of the effect of the electrification of air within a glass vessel, upon the pressure of the air on the walls of the containing vessel. A large three-necked Wolff's bottle was used, the three openings being provided with rubber stoppers which had been treated with vacuum wax. The bottle had a volume of 9.6 litres. Through the central stopper was passed a copper wire to which were attached 150 pins. The outer part of this wire was in contact with a metal conductor, having a length of about ten feet, which extended to a point near the terminals of the influence machine. This conductor was symmetrically placed with respect to the terminals. It terminated in a disk of copper having 150 pins whose heads were soldered to one of its faces. This many pointed terminal could be placed directly in front of either of the large knobs of the machine, at a distance of 10 cm., the other knob, or terminal, being grounded.

A U-shaped water gauge was mounted in another stopper of the flask. In the third stopper of the flask a tube with a bulb containing calcium chloride was mounted, this tube being provided with means for connecting the confined air with the outer air. The condensers were wholly removed from the machine. The glass bottle was placed upon a sheet of heavy plate glass.

When the discharge-knobs of the machine were near enough together so that the brush discharge between them was accompanied by faint disruptive effects, the pressure within the flask could be increased by about two grams-weight per sq. cm., the effect of the negative electrification being somewhat greater than that of the positive. When the knobs were far enough apart to prevent disruptive discharges, no luminous effects being observed within the flask, the change in pressure due to either terminal was reduced to between one and two mm. as shown by the water gauge. After the pressure due to electrification of the air had reached a final limit, a transfer of the many pointed collector to the front of the other terminal, would result for a time in a slow decrease in pressure, and then in a slow increase to the former limit. The decrease in pressure did not begin until the discharge from the other terminal had begun. Heat effects had been practically eliminated.

If the gas contains moisture a permanent decrease in pressure at once results, due to condensation of vapor upon the sides of the vessel.

These results seem to indicate that there is an electrical condition of the gas, for which the Boyle-Gay-Lussac constant is a minimum. When this condition is reached, the second term of equation (1) is zero, as applied to molecules of gas.

An attempt has been made to determine whether or not the value of the gravitation term of Eq. (1) can be affected by electrical action, when the effect represented by the final term is eliminated. The apparatus used was

a modified form of that used by Cavendish. The suspended masses consisted of two lead tubes, each being about 15 cm. in length, each having a mass of 50 grams. They were mounted around the ends of a brass tube 91 cm. in length, and having a mass of 30 grams. This tube was suspended upon two loosely twisted threads of silk fibers, 180 cm. in length, whose distance apart was approximately 0.4 cm. The twist was removed from these threads by hanging upon each a mass of 65 grams. This formed a very sensitive bifilar suspension. The suspended masses were wholly surrounded by a metal shield of rectangular form 10x12.5 cm. in cross section. The suspension fibers were enclosed in a metal tube, having a torsion head at the top, thus providing means for properly adjusting the position of the brass tube. The ends of the rectangular shield were provided with metal caps, fitting closely into its ends. They entered the shield a distance of 2.5 cm. An opening at the middle of the shield, in front of a mirror mounted upon the suspension wire, served for observation of position by means of a telescope and scale. This opening was covered by a sheet of glass which was sealed to the shield by means of sealing-wax. The window was covered with a metal wire screen having about 5 wires per running cm. The mirror was observed through this wire screen, the telescope being focused upon the scale at the telescope. A change of one scale division represented a change of 2.36 minutes of arc in the position of the suspended tube. The suspended masses and the brass tube on which they were mounted were surrounded by sheets of asbestos paper, which fitted into the caps at the ends of the shield, and fitted loosely the interior of the shield. These two linings formed extensions of the end caps and were intended to prevent a convection of the air within the shield.

The large masses each consisted of two fifty-pound weights placed one upon the other and mounted upon heavy columns of rubber. They were separated from the metal shield by a space of about 2 cm. In this space was

placed a sheet of glass and three layers of asbestos paper.

The shield was mounted upon a heavy piece of timber and rested directly upon a sheet of glass. It was also wrapped with asbestos paper. The long suspension tube was held in stable position by three heavy silk cords attached to surrounding cases, and loaded with a series of distributed masses, about 25 in number, and having a mass varying from 50 to 100 grams each. The metal shield was loaded with two ten-pound masses of iron and its sides were clamped with wooden clamps in order to quiet any vibrations in the shield. The large iron masses and the metal shield were connected with each other by large copper wires, leading to a spark-knob mounted upon the table. Another spark-knob, mounted on an independent support, was provided with a discharge terminal, consisting of 150 pin-points, the heads of which were soldered to a copper disc. The entire apparatus was mounted upon a massive table. The floor of the room was of reinforced concrete. The discharge terminal was connected with the influence machine in an adjoining room, by means of brass rods hung upon silk cords. The machine was operated by a synchronous electric motor. The discharge knobs at the machine were separated so that no disruptive discharges were possible. One terminal of the machine was grounded. There were no condensers on the machine terminals.

The time interval of a to and fro vibration of the suspended masses was 485 seconds. When at rest there appeared to be no disturbance of any kind. The reading would somtimes remain constant for hours. At other times the reading slowly changed. It often varied throughout a day through 20 scale divisions. It was found that the large masses appeared to attract the suspended masses with a varying force, even when the former were hung from the ceiling above. Sometimes they appeared to repel the suspended masses. These varying effects were finally traced to very moderate changes

in the temperature of the room. It was found that the flame of a wax candle, placed fourteen inches from either of the suspended masses, exerted a marked apparent attraction for them. When a sheet of glass and two sheets of asbestos paper were placed between the candle flame and the metal shield, it being provided with a wrapping of asbestos paper in addition to the inside lining of the same material, an apparent attraction resulted. A change of 20 scale divisions would then result in two minutes. This result was obtained with either of the suspended masses, when the other was protected by the two 50-lb. masses and other means before mentioned. Fluctuations in the flame of the candle due to the condition of the wick produced observable effects. When the outer wall of the screen was rising in temperature more rapidly on one side of the suspended mass than on the opposite side, this mass moved towards the warmer side. This was apparently due to the convection effect of air within the lining of the metal screen.

The suspended rod bearing the small masses was below the central axis of the enclosing shield. If one side of the shield was warmer than the opposite side the suspended rod would be in a slowly drifting current of air, which would urge it towards the warmer side of the screen, or away from the colder side. The temperature of the large masses lagged behind that of the screen in the small daily changes in the temperature of the room.

The effect of a noiseless discharge from the pin-point terminal into the air around the knob connected with the screen and the large masses, was to produce an apparent decrease in the attraction of the large masses for the suspended masses. This result was obtained when no trace of disruptive discharge could be detected. After the extreme displacement thus produced had been reached, the distance between the pin-point terminal, and the knob connected with the shield and the large masses, was increased from 15 to about 90 cm., the charged bodies being then grounded. This was done by means of a

fine wire attached to an insulated rod, which could be laid upon the floor of the room, or lifted into contact with a rod, one end of which rested upon one of the large masses. The pin-point terminal was meantime made to face another grounded conductor. The suspended masses then swayed to the other extreme position during the next four minutes. By a repetition of this operation, the arc of vibration could be increased from one or two scale divisions to twenty-six in an interval of an hour. The average of the extreme readings of consecutive vibrations, usually showed slow progressive changes of two to five scale divisions per hour. Sometimes the average reading showed a decrease and sometimes an increase. The results were of the same order of magnitude whether the masses were connected with the negative or with the positive terminal of the machine, although most of this work has been done by the positive "discharge."

It was suspected that this result might be due to a slight rise in the temperature of the walls of the metal shield. If this were the case it must be assumed that while the gap at the pin-point terminals was least, the rise in temperature was least in that part of the sides of the metal screen facing the large external masses.

In order to examine this influence, a delicate air thermometer was extemporized. The bulb consisted of an oil-can having a capacity of 4.5 litres (one gallon). Connected by a rubber hose with the nozzle of the can was a horizontal tube of glass, having a length of 75 cm. and an internal diameter of 0.76 mm. Within this tube was a short column of water, serving as an index. The entire device was insulated upon glass supports. A candle flame 20 inches distant from the can caused the index to move over a distance of 2 cm. in 15 minutes. When the candle flame was removed and the can was electrified and in electrical contact with the large masses and shield, no change in the position of the index column could be detected, when observed by means of a telescope.

The large masses were then wholly enclosed in two metal boxes, from which the masses were insulated. The masses rested upon rubber blocks placed upon the bottom of the boxes, and each box was mounted upon rubber blocks which rested upon plates of glass. The masses were in the same position as in the work above described. The boxes were separated from the shield, enclosing the suspended masses, by the plates of glass and the asbestos paper.

The two metal boxes and the metal shield were then electrified precisely as has been done before. It was then found impossible to increase the arc of vibration of the suspended masses, although the operation was continued for several hours. If the former results had been due to heat effects, they should have produced the same results in this case. The large masses were removed from the enclosing boxes. The empty boxes and screen were then electrified as before.

No change in the amplitude of vibration could be produced.

These results seem to indicate clearly that gravitational attraction between masses of matter depends upon their electrical potential due to electrical charges upon them. To assume a special case, such as exists when the gravitation constant is being determined, Newton's law holds only when the common potential of the two bodies is such that their gravitational attraction for each other is a maximum. If the two masses are not separated by a metal shield and their common potential is that of the earth, these masses will repel each other by a force represented by the final term in Eq. (1) and the value of K will also be diminished, if the above conclusions are correct. If the two masses are separated by a metal shield, this final term will be eliminated, but the value of K will be diminished and may seem to be variable, if there are local variations in the potential of the earth. By adjusting the potential of the attracting masses by well known means we may hope that the real value of K and the

absolute potential of the earth may be determined. This is a problem for the future to solve.

In the work discussed in this paper an effort has been made to eliminate heat effects from all sources. It may be that alternating discharges from a high potential transformer would produce more marked effects than have been observed by the methods above described. The surging of negative electrons within the large attracting masses would be greatly increased. This would also involve heat disturbances, the effect of which would cast a doubt upon the results. Under the conditions in which this work was done the amplitude of vibration of the suspended masses sometimes changed in a way that seemed to discredit the above conclusions. It was finally found that variations in the illumination of clouds in the northern sky produced marked effects upon the position of the suspended masses. The apparatus was fifteen feet distant from five large windows in the north wall of the room. The variation in radiation from such clouds was occasionally followed by a marked change in the amplitude of consecutive vibrations. After such disturbances and others not here referred to had been eliminated, there still remained distinct evidence that the value of the gravitation constant as it has been determined, is dependent upon the electrical potential of the attracting masses, when the effect represented by the final term in equation (1) is wholly eliminated by a metal screen.

Plans are now being prepared which will, it is hoped, result in a determination of the change which can be produced in the value of the gravitation constant, by electrification of the larger masses.

The writer desires to acknowledge the financial aid granted to him by the Carnegie Institution of Washington.

EXPLANATION OF ILLUSTRATIONS.

Plate XLIV; Fig. 1. Fusion of lead wire by negative discharge.
Plate XLIV; Fig. 2. Explosion effects due to positive "discharge."

Issued July 28, 1916.

FIG. 1.

FIG. 2.

FUSION AND EXPLOSION EFFECTS ON LEAD WIRE.

Transactions of The Academy of Science of St. Louis.

VOL. XXIII. No. 5.

GRAVITATIONAL REPULSION.

FRANCIS E. NIPHER.

Issued November 8, 1917.

GRAVITATIONAL REPULSION.*

FRANCIS E. NIPHER.

In a former paper published by the Academy on July 28, 1916, the following passage may be found:[1]

"These results seem to indicate clearly that gravitational attraction between masses of matter depends upon their electrical potential due to electrical charges upon them."

Every working day of the following college year has been devoted to testing the validity of the above statement. No results in conflict with it have been obtained. Not only has gravitational attraction been diminished by electrification of the attracting bodies when direct electrical action has been wholly cut off by a metal shield, but it has been made negative. It has been converted into a repulsion. This result has been obtained many times throughout the year. On one occasion during the latter part of the year, this repulsion was made somewhat more than twice as great as normal attraction.

The large masses used in this work were spheres of lead ten inches in diameter. They were mounted upon blocks of dry wood, which were mounted upon caster-wheels provided with roller bearings. The wheels rested upon heavy sheets of hard rubber. The suspended masses were two spheres of lead, having a diameter of one inch, mounted upon the ends of a brass tube. Their distance apart, from center to center was 91.5 cm. They were hung upon two untwisted threads of silk fibers, forming a bifilar suspension. The length of the threads was 179 cm., and the distance between them was about 3.4 millimeters. Near the top of the long metal cylinder

---

* Presented by title to The Academy of Science of St. Louis, Oct. 22, 1917.

---

[1] Trans. Acad. of Sci. of St. Louis, XXIII, No. 4, p. 173.

enclosing these suspension fibers, was a lateral brace formed of two bars of hard rubber, about 30 cm. in length. The ends of these bars formed a right angle against which the vertical suspension cylinder was pulled. These rubber bars formed the ends of two long bars of wood attached to the tops of instrument cases along adjoining sides of the room. The bars were also supported by a framed structure. Silk cords attached to the cases ran along the two bars and were tied to the suspension cylinder. Weights distributed along these cords served to hold the cylinder against the ends of the rubber bars. Vibrations of the suspension cylinder were thus wholly eliminated. The torsion head forming the top of the cylinder was provided with a rod which extended radially outward to a distance of about 20 cm. By this means the torsion head could be turned in order to put the suspended masses into vibration. The top of the suspension cylinder had a similar rod clamped to it having an upward projecting stop, by means of which the torsion head could be returned to the original position. Change in the temperature of the air within the shield resulting in a change in volume was provided for by the outflow or inflow around the torsion head.

The enclosing case was of the general form used by Cavendish. In the early part of the year it was formed wholly of metal. It rested upon insulating blocks of rubber, which were mounted upon two long pieces of timber having a cross section of 4x4 inches. These timbers rested upon a massive table, which was on a floor of reinforced concrete within a building having granite walls. At the central part of the metal shield the dimensions were 5x5 inches. A narrow slit on one side covered by a small plate of glass sealed to the shield, served for observing the movement of the suspended masses by means of a telescope and scale. At the outer ends of the shield, the lateral dimension was about 15 inches. This form was chosen in order that the suspended masses and the brass tube upon which they were mounted could be in-

closed by a cylinder of copper wire gauze, between which and the outer screen was very loosely packed cotton fiber. A thin layer of cotton was placed at the ends of the screen, being also held in place by wire netting. This was designed to diminish convection effects.

The body of the observer was wholly below the level of the table. Radiation of heat from the head to the screen was cut off by sheets of heavy cardboard.

The two rooms used for this work were wholly disconnected from the heating system of the building. During the day the temperature of the large masses was usually slightly lower than that of the shield around the suspended masses. This temperature difference never exceeded 1°.5 C.

The large masses were placed at the ends of the screen or shield in line with the rod upon which the small masses were mounted, in order to determine their effect upon the time of vibration of this bifilar pendulum. The large masses and screen were in direct metallic connection, and the air around them was electrified by a discharge from pin-points. A disc armed with 150 pins was placed with the pin-points 4 cm. from each of the large masses. A noiseless discharge was delivered from the points of the pins.

Let T represent the time of vibration when the masses were away.

Let T_1 represent the time of vibration when the masses are in place.

Let T_2 = the time when the masses and screen are electrified.

Then

$$T = 2\pi \sqrt{\frac{I}{m\, g\, \frac{d^2}{l}}} \qquad (1)$$

Here m is the suspended mass, $2d$ the distance between the two silk fibers on which it is suspended, and l their length. I is the moment of inertia.

When the large masses are in place

$$T_1 = 2\pi \sqrt{\frac{I}{D + 2\,b\,G\,\frac{M\,m'}{r_2}}} \qquad (2)$$

Here D is the directive constant of Eq. (1), b the distance between the centers of the two suspended masses m', and r the distance between the suspended masses and the large masses M. The equivalent of the brass rod is included in m'.

When the large masses are electrified, if the time of vibration is increased to T_2 and we assume that this is due to a decrease in the value of the gravitation constant G, then

$$T_2 = 2\pi \sqrt{\frac{I}{D + 2\,b\,G\left(1 - \frac{n}{100}\right)\frac{M\,m'}{r^2}}} \qquad (3)$$

From these equations

$$\frac{n}{100} = \frac{T_2^2 - T_1^2}{T^2 - T_1^2} \times \frac{T^2}{T_2^2} \qquad (4)$$

The time of vibration was determined by means of a chronograph belonging to the department of astronomy of the University. The key was snapped when the mean reading passed the cross-hair of the telescope. The mean reading was obtained from the reading of the four extremes of the two complete vibrations which immediately preceded. The values here given are the mean of six complete to and fro vibrations and the probable error does not in any case exceed 0.25 sec.

Observations March 10, 1916.

$T = 623.0$ sec.
$T_1 = 614.5$ sec.
$T_2 = 625.0$ sec.

By Eq. 4, $\frac{n}{100} = 1.23$

When T was determined the temperature of the air in the room was 15°.5 C $= t_a$

The temperature of the screen was $t_s = 15°.2$ C.

When T_1 was determined,

$$t_a = 17°.4 \text{ C}$$

The temperature of the two large masses was 16°.4 and 16°.6.

These values were determined by means of four thermometers reading to tenths of a degree. The bulbs were placed in contact with the masses, and covered with a layer of cotton batting.

When the readings for T_2 were finished

$$t_a = 18°.0 \text{ C}$$
$$t_s = 17°.9 \text{ C}$$

The temperature of the large masses was 17°.7 and 17°.8.

On a former occasion, when the bifilar suspension was different, it was found that placing metal vessels containing a litre of water having a temperature of 28° C. at the beginning of the experiment, and 24° at the close, in the positions occupied by the large masses, the temperature of the air and shield being 13°.8, the value of T was increased from 644.2 sec. to 652.5. The warm vessels were in contact with the shield.

When the metal vessels contained water and ice, the temperature of the air and shield being 12°.0, the value of T was decreased by 25 seconds.

These results seem to indicate clearly that convection of the air within the shield had no material effect upon the values of the quantities used in computing the value of n in Eq. 4.

It apparently follows that the value of the gravitation constant was made negative by the process described. Attraction was converted into a repulsion. The influence machine was unusually active by reason of fresh drying

material in the case in which it was enclosed. On other days the value of G was decreased by 16, 23, 27, 69, 77, 134 and 184 per cent of its initial value. It is not claimed that these are results of any high degree of precision. During the first week while the bifilar method above described was being tested, the time of vibration during a period of two hours was found to be very constant. For example, in the first determination made on October 23, the mean position of the suspended masses was determined from readings of the extremes for several vibrations. The key was then snapped for six readings when the mean reading passed the cross-hair of the telescope. The mean reading was determined in each case by a computation from previous readings. It was found to be very constant. After lunch the same operation was repeated. This gave six readings of the time interval of 7 complete to and fro vibrations, with data for determining the probable error of the mean. The result was 653.45± 0.062 seconds. The probable error was sometimes three times as great as the above value and the mean value varied from the above value on other days by between one and two seconds. An error in the value of n might amount to three or four per cent. The cause for these variations proved to be a difficult problem. The silk threads were very loosely wound, and before they were put in place a weight equal to half the weight of the entire suspended mass was hung upon each of them for several days. They then seemed to be in permanent condition. The breaking stress was about five times that which was thus applied to them.

The causes for the variation in the time of vibration were thought to be possibly due to a breaking of some of the fibers in the threads which might result in an entanglement between the two threads, or which might result in an unequal division of the load between them. It was sought to eliminate the former source of error by applying vaseline to the threads. This did not appre-

ciably change the result. It was finally decided to check the results above described by placing the large masses on alternate sides of the suspended masses and observing the deflection due to gravitational attraction.

In order to maintain equality of stresses in the two threads, which had been hung around a hook attached to the torsion head, they were hung around a pulley, having a diameter of one inch. Below were two adjustable pulleys. The threads approached each other around these two pulleys, and their distance apart could be so varied as to make the threads parallel within the long suspension cylinder. The metal shield before described was replaced by one having equal width from end to end. The top, bottom and ends were of wood 7/8 inch in thickness. A sketch of this wood frame is shown in vertical section in Fig. 1.

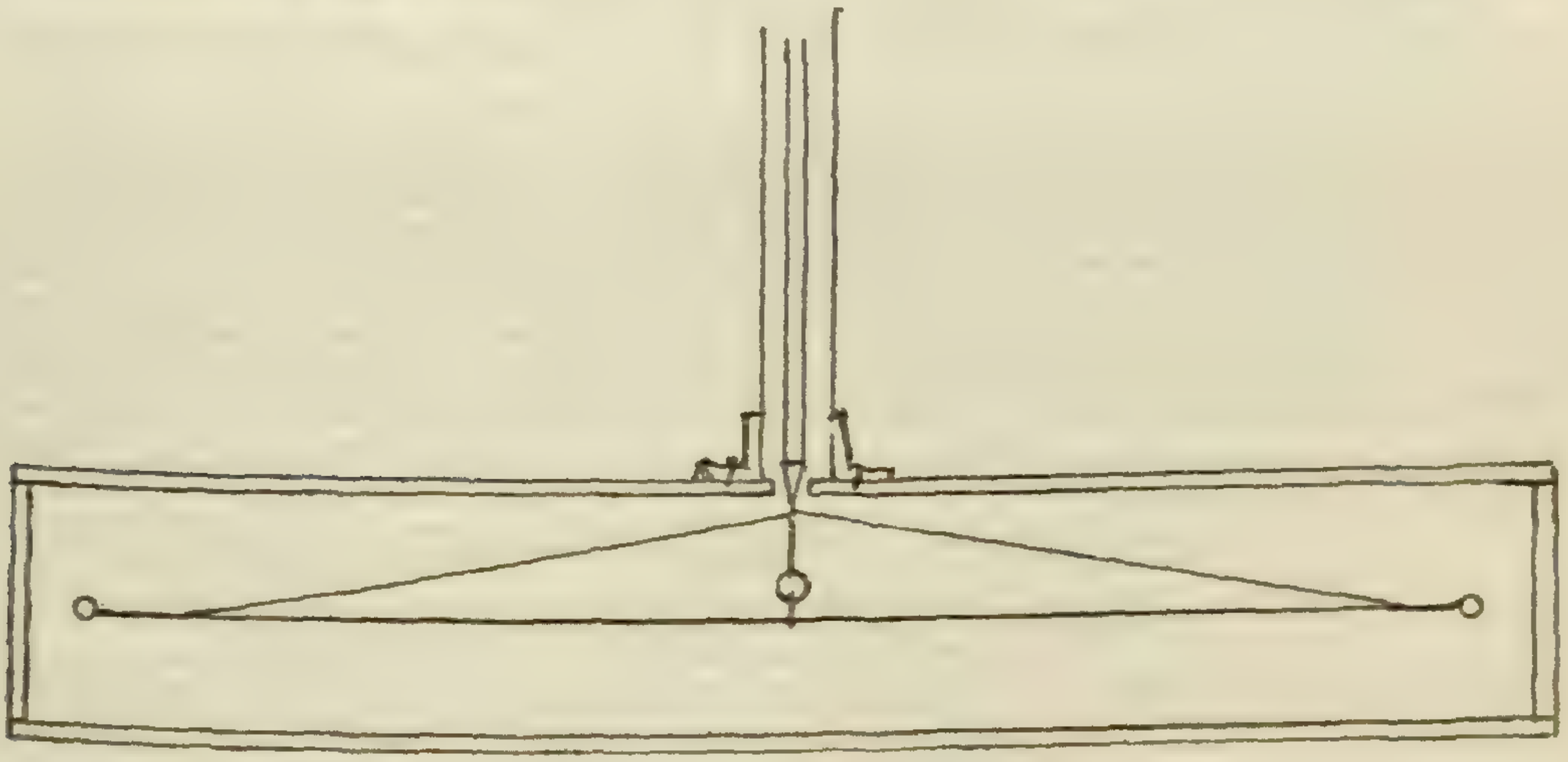


Fig. 1.

This wood frame was varnished with shellac and all points of contact of its parts were closed. The sides of this frame were each closed by two layers of heavy cardboard outside of which was a sheet of flexible tinned iron. They were clamped to the wooden frame by means of wood bars screwed to the bottom, top and ends. The edges of the cardboard were then sealed by means of beeswax applied by means of a hot iron. The entire device as thus described was then enclosed by a metal shield.

A cross section through one of the suspended masses is shown in Fig. 2.

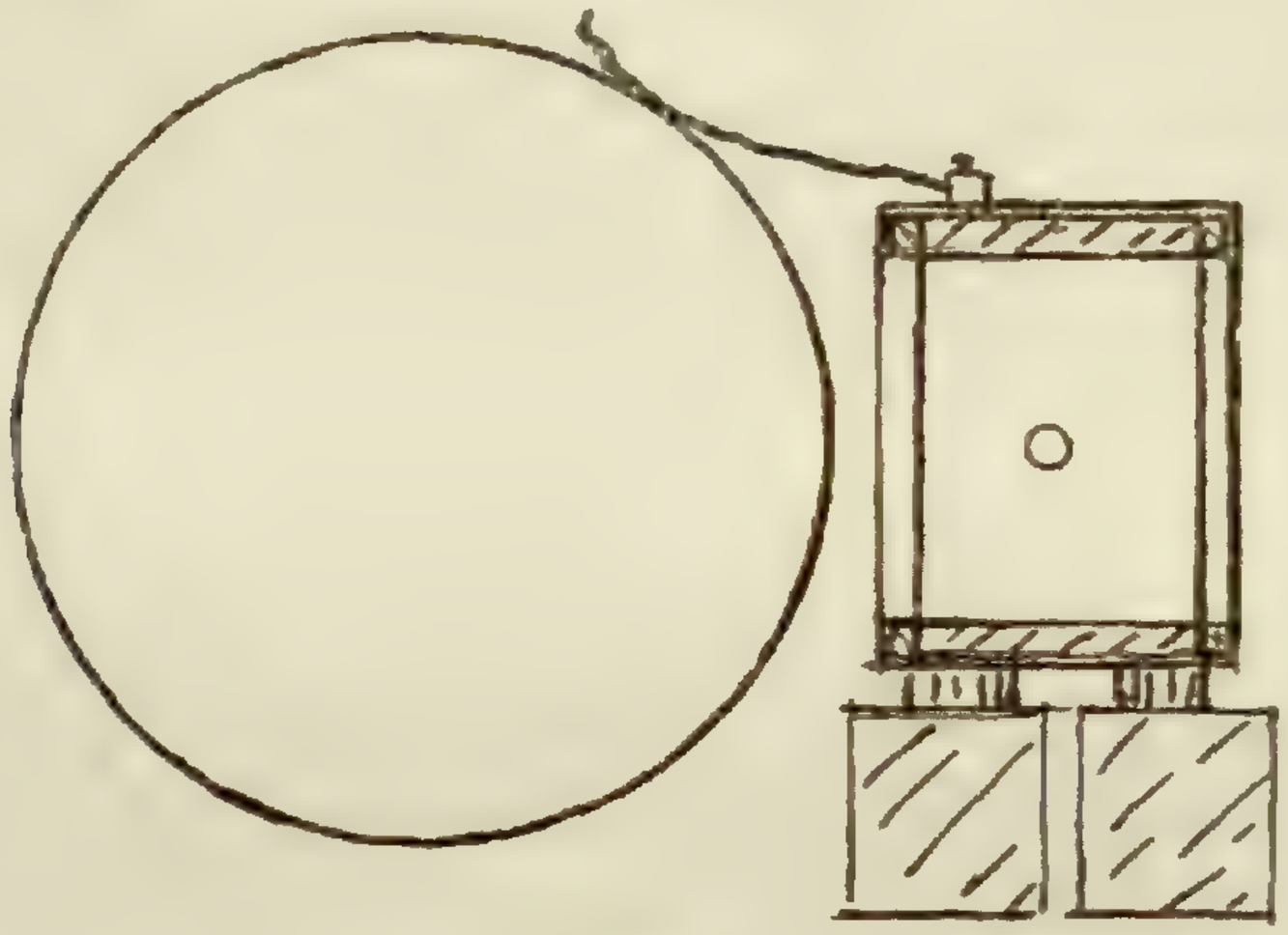


Fig. 2.

This outside metal shield was not air-tight. It was formed of sheets of flexible tinned iron, the parts of which overlapped. They were tied in place by windings of twine. It was considered an advantage to allow convection currents which might form in the layer of air between the two sheets of metal forming the sides of the enclosing case some opportunity to escape into the outer air.

The large masses *M* were thus separated from the suspended masses *m'* by two superposed sheets of cardboard and a sheet of metal, which were clamped and sealed to the wood frame of Fig. 1, a layer of air about 7/8 inch in thickness, and the outer sheets of metal, forming part of the metal shield enclosing the entire device.

Both of the masses *M*, and the shield around the suspended masses, were insulated as before described. The large masses and the shield around the suspended masses were connected by means of large copper wires. Between the masses *M*, and the shield were sheets of glass, not shown in Fig. 2.

In the work to be described, the air around the large masses and screen was electrified by a noiseless discharge from 800 pin points which were mounted in strips of metal hung upon insulated metal rods three feet from the

large masses and screen. A sketch of this arrangement is shown in Fig. 3. The sheets of metal which carried these pins were punched with small holes, through which

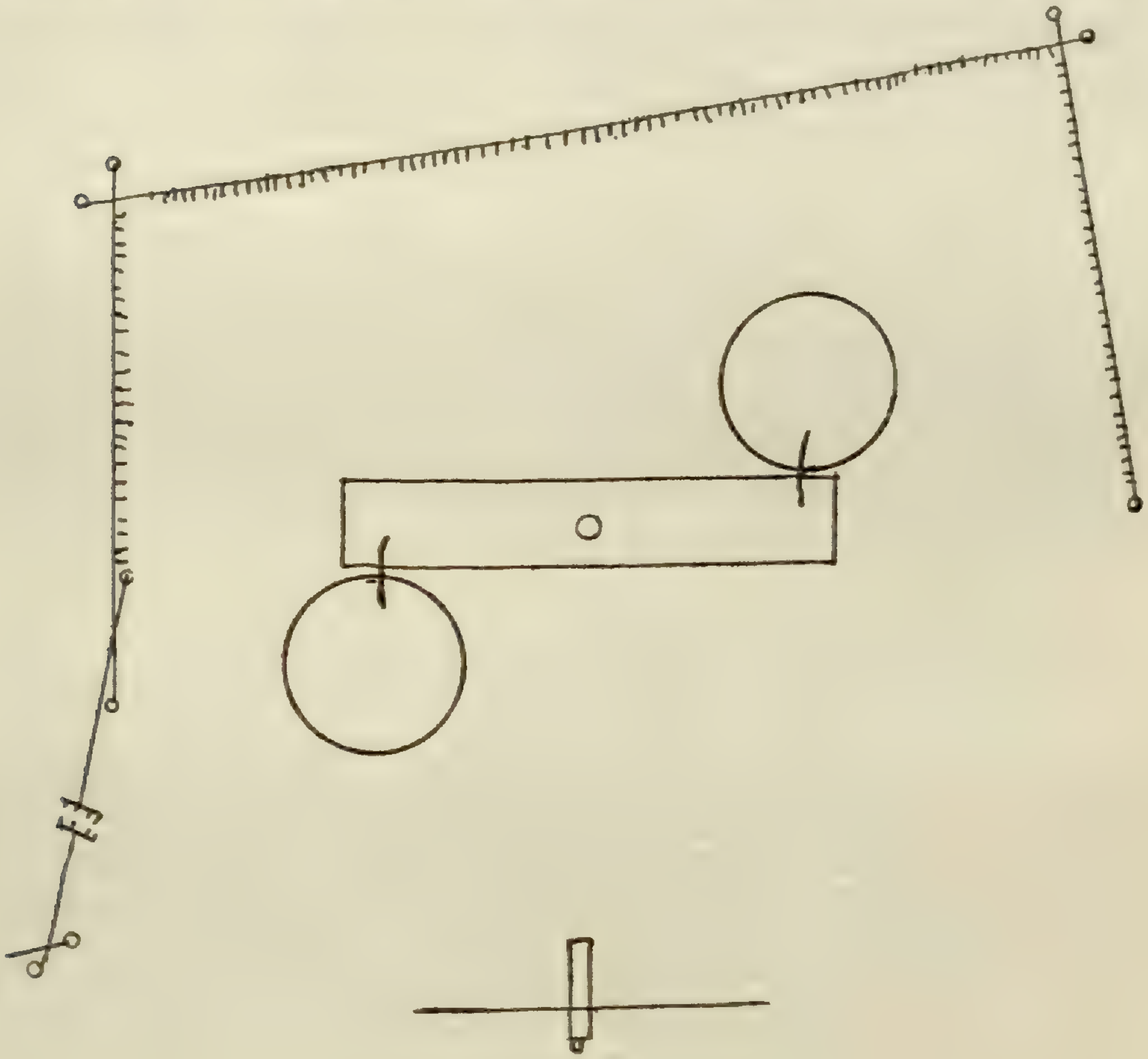


Fig. 3.

the pins were inserted and the heads were then soldered to the sheets of metal, which were then hung upon the insulated rods by metal hooks. At one end this line of rods terminated in a disc of metal upon which 150 pins were mounted. Facing this disc was a duplicate, the points of the pins in the two discs being three or four inches apart. This last named disc was directly connected with one terminal of an influence machine in an adjoining room, the other terminal being grounded on a water pipe. There were no condensers attached to the machine, and the knobs were widely separated. There were no gaps in the line of conductors. The machine was

enclosed in a glass case containing drying material, and it was driven by a single-phase motor. Placing the large masses in the position shown in Fig. 3 at the time when the work to be described began, increased the scale reading by 0.40 cm.

An illustration of the results obtained is shown in Plate XLV. In each case the masses had been grounded during the preceding night. The scale was displaced in order that the two diagrams might be shown on the same plate, without interference. On the lower diagram the arrangement of apparatus was as shown in Fig. 3. The hour of the day is laid off upon the horizontal axis. The scale reading in cm. is along the vertical axis. One mm. represents an angle of 2.6 minutes of arc. The negative terminal was applied at 9:38 a. m. On the diagram the arrow indicates the time. At 10:12 a. m. the terminals were reversed, an operation which required a few seconds of time. At 11:30 the machine was disconnected. There was evidence shown in the drop in the reading at 11:20 that the reading would begin to decrease. The upper diagram of this plate shows results obtained on May 4. Here the positive terminal was first applied at 9:35 a. m. The terminals were reversed at 10:24 and the machine was stopped at 11:20, the readings being continued to 12:05 p. m. In this work the conductors upon which the 800 pins were supported were directly connected with the large masses and shield.

When direct contact was made between the pin-conductors and the large masses, the changes took place more rapidly than when the air surrounding the masses was supercharged with negative corpuscles emitted from the pin points, or when the reverse action took place, this alone being depended upon to change the potential of the masses. The most interesting feature of this work is the complete elimination of the possibility that the apparent decrease in the attraction between these masses was due to the convection currents of air resulting from heat effects. Reversing the terminals would not reverse these heat effects.

The possibility that one terminal of the machine produced greater heat effects than the other, the deflecting effect being decreased when the terminal producing the lesser heating effect was applied is also eliminated. It matters not which terminal is first applied. The result is the same, and has been obtained many times.

During the afternoon of May 4 the operation represented in the upper curve of Plate XLV was repeated, the positive terminal being first applied. A result of precisely the same kind was obtained.

The upper curve of Plate XLV also means that the gravitational attraction between the masses at 9:35 a. m. had been decreased by about 110% at 10:10 a. m. Gravitational attraction had been decreased to zero, and had then been converted into a repulsion. An hour later it had regained its initial value. On the afternoon of June 1, at 2:30 p. m., it was decided to change the electrical condition of the suspended masses. One of the end caps forming the outer metal shield of Fig. 2 was removed. A hole which had been bored through the wood frame, and which had been closed by a rubber stopper, was opened. A glass tube was passed through the opening, about two centimeters beyond the inner surface of the wood frame. A copper wire to the end of which the head of a pin had been soldered, was passed through the tube, the point of the pin projecting slightly beyond the end of the tube. The wire was about six inches in length. The apparatus was arranged as shown in Fig. 3. The positive terminal of the machine was used in draining negative corpuscles from the air within the shield around the suspended masses. A slow change of 1.2 cm. or 12 scale divisions in the scale reading was produced. The terminal was disconnected when this deflection had been produced, and the machine was stopped. The tube was removed, the end cap of metal was replaced and the large masses and shield and the pin-point conductors were grounded until the next day. The mean reading had not been appreciably changed.

At 10:25 a. m., June 2, readings were taken until 10:43 a. m. The suspended masses were at rest.

The positive terminal was then applied. The result is shown in Plate XLVI.

The arrangement of the apparatus was that shown in Fig. 3. A sudden decrease in the attraction occurred. It was so sudden that forced vibrations were impressed upon the suspended masses. The vibrations were small, and only occasional readings of consecutive extremes were recorded. At 2:20 p. m. the terminals were reversed and at 2:32 p. m. direct contact of the pin-point conductors and the large masses and shield was made. The attraction at once increased very rapidly. The absolute zero of potential was reached and passed in a less time than that of a semi-vibration. Forced vibrations were impressed upon the suspended masses as the attraction began to decrease. These vibrations were observed, and the extremes were read until 3:30 p. m. The masses were then being repelled by a force nearly twice as great as the initial gravitational attraction. Direct contact between the discharge points was removed, but the masses were not grounded. On Monday, June 4, at 9:20 a. m., the masses were vibrating over a very small arc (about one scale division). Readings were taken at some of the extremes of vibration, which were sufficient in number to show that the mean reading was constant until 11 a. m. These readings are represented in Plate XLVII. The masses were still repelling each other, with a force about 50 per cent. greater than the initial attraction on the morning of June 2. This conclusion seemed beyond belief at the time but subsequent results on that day seemed to make it a necessary conclusion. At 11:03 a. m. the positive terminal was applied and direct contact between the large masses and the pin-point conductors of Fig. 3 was made. The time is represented by the arrow marked + D. C. on Plate XLVII.

At once the attraction began to increase. The masses were swaying in the opposite direction at the time when

contact was made. A maximum reading was obtained at 11:18 a. m. and the masses swayed in the opposite direction during the next 14 minutes. Forced vibrations were again impressed upon the suspended masses, but they were less violent in character than those at the close of the observations represented in Plate XLVI. At 12 observations were discontinued until 12:48 p. m., when the reading showed only a slight decrease. At 1:00 p. m. the terminals were reversed and the direct contact was removed. The conditions then were as represented in Fig. 3. At this time the apparent decrease in the initial attraction which existed at the beginning of the observations on June 2, was about 340 per cent. In other words the apparent repulsion was then more than twice the initial attraction. This conclusion seems to be fully justified by the amazing increase in the attraction which at once resulted. At 1:53 p. m. direct contact between the pin-point conductors and the shield and large masses was made by dropping a wire into position. It was removed at 2:02 p. m. Forced vibrations were again impressed upon the suspended masses. The machine was stopped at 2:19 p. m. and I was called away for an hour. A few readings taken between 3:12 and 3:22 p. m. shown at the close of Plate XLVII indicate that the attraction had then approached closely to the initial value on the morning of June 2.

It will of course be understood that no attempt has been made to secure results of precision in this work. The only aim has been to determine whether or not it would be justifiable to construct the much more expensive apparatus which will be required for such results. The suspended masses must be capable of being electrified independently and the enclosing walls must surround them in symmetrical form, so that their inductive action will not produce deflection of the suspended masses. If they are suspended in highly rarefied air, it may be necessary to use a metal wire rather than a quartz fiber, which must then be attached to an insulated torsion head. A

modified form of the apparatus used by Boys will be required. The necessity for such a construction seems to be justified by the evidence already obtained, that if the potential of either of the attracting masses M and m' is zero absolute, gravitational attraction between them will not be affected by varying the potential of the other mass. The gravitation, constant as it has been determined by methods which made use of some form of the Mitchell-Cavendish apparatus, would have a maximum value when either or both of the masses had a potential of zero absolute.

Neglecting the inductive effect which electrified masses have upon each other, it is possible that the amended equation for gravitational attraction between them is

$$A = K \frac{m\,m'}{r^2} - K' \frac{Q\,Q'}{r^2}$$

It seems possible that the effect of the charges Q and Q' upon gravitational attraction between the masses m and m' may be a surface effect. If so the values of Q and Q' may be replaced by RV and $R'\,V'$, where R and R' are the radii of the two masses and V and V' their potentials due to those charges.

The above equation may also be written

$$A = K\left(1 - \frac{n}{100}\right)\frac{m\,m'}{r^2}$$

Here it is assumed that the masses are so electrified as to diminish their normal attraction for each other by n per cent. From these two equations the values of m and m' being replaced by their values in terms of volume and density.

$$K' = K\,\frac{n}{100}\,\frac{16}{9}\,\frac{\pi^2\,\rho^2\,R^2\,R'^2}{VV'}$$

If this equation really represents the conditions imposed upon the masses, it appears that for any given decrease in gravitational attraction the potentials of the masses must be directly proportional to the surface areas

of the masses. Small planets having high and perhaps varying potentials might not follow Newton's law. The value of n would be large and variable.

In the work represented in Plate XLVI, if we assume that when n was 100, the attraction between the masses being reduced to zero, the potential of the large masses was 30,000 volts, or 100 E. S. C. G. S. units, and that of the suspended masses was 10 volts or 1/30 E. S. C. G. S. unit, then the last equation would give for K':

$$K' = 165800\ K$$

This result is based upon assumptions and estimates. One inference may be drawn from it. There is nothing here to indicate that the force whose action is represented by Newton's term, should not be the main factor in determining the motion of the masses in our planetary system.

The large masses represented in Fig. 3 were replaced by boxes of metal, filled with loose cotton batting. They rested upon insulators. They were separated from the screen by sheets of glass, and were put in metallic contact with it by means of copper wires. Precisely the same treatment was applied to this system as was given when the large masses were in place. No change in the position of the suspended masses could be detected.

The large masses being in position as before described, spring contact brushes were fastened to the blocks of wood upon which the large masses rested. They made contact with the large masses at points midway between the top and bottom of the spheres. A direct current of 20 amperes was sent through the two large masses. The axis of the line of flow was in one case practically coincident with the line through the centers of gravity of the two masses nearest to each other. The direction of flow was either from the outside contact, to the one nearest the screen, or the reverse, the direction of flow being reversible by means of a double switch. The screen was insulated from the two large spheres. No effect upon

the suspended masses could be detected. If any effect was produced it was very small. The large masses were turned 90° in position, with a like result.

An alternating current of 20 amperes was applied. No effect could be detected when the masses were in the latter position. When the lines through the points of contact of the brushes with the large spheres was coincident practically with the line through the centers of gravity of the two masses nearest to each other, the gravitational attraction was quickly reduced to zero, and made negative. The repulsion was about 50 per cent of the normal attraction. To bring about this result required about fifteen to twenty minutes of time. When the double switch was opened, so that the large masses were wholly separated from the source, and the masses were grounded it required between two and three hours for the large masses to recover from the shock which they had received. This has been repeated many times, with no discordant results. It may be that the parts of the large spheres which are most affected by the alternating current are those parts near the brushes. If there are heat effects, they tend to oppose the observed effect. Burning candles replacing the large masses cause a change in the reading in the opposite direction from that of the alternating current, the glass plates being removed. This is due to convection currents within the screen.

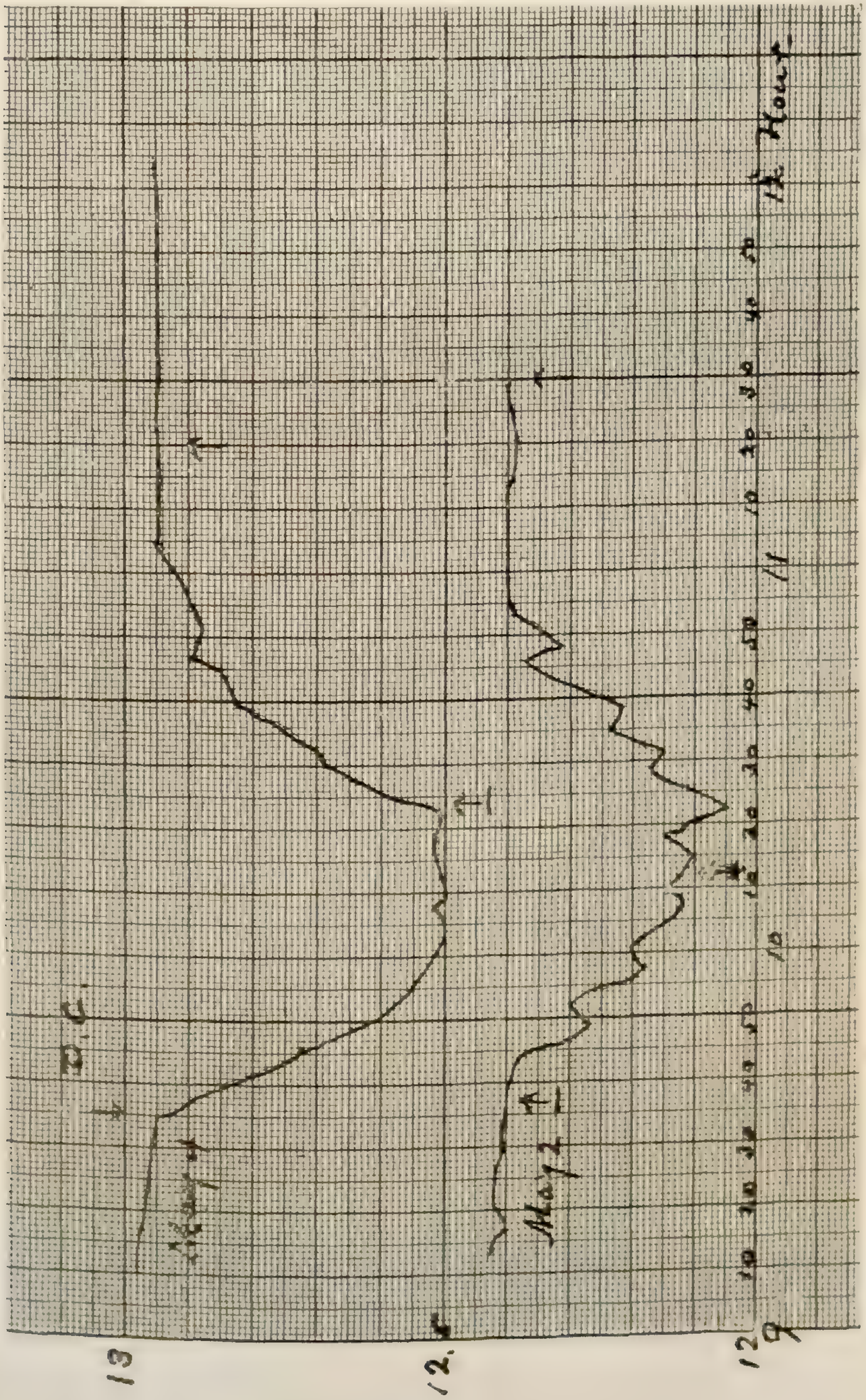
The work here described has been done in a private laboratory in the second story of Eads Hall, now occupied by the physics department of Washington University.

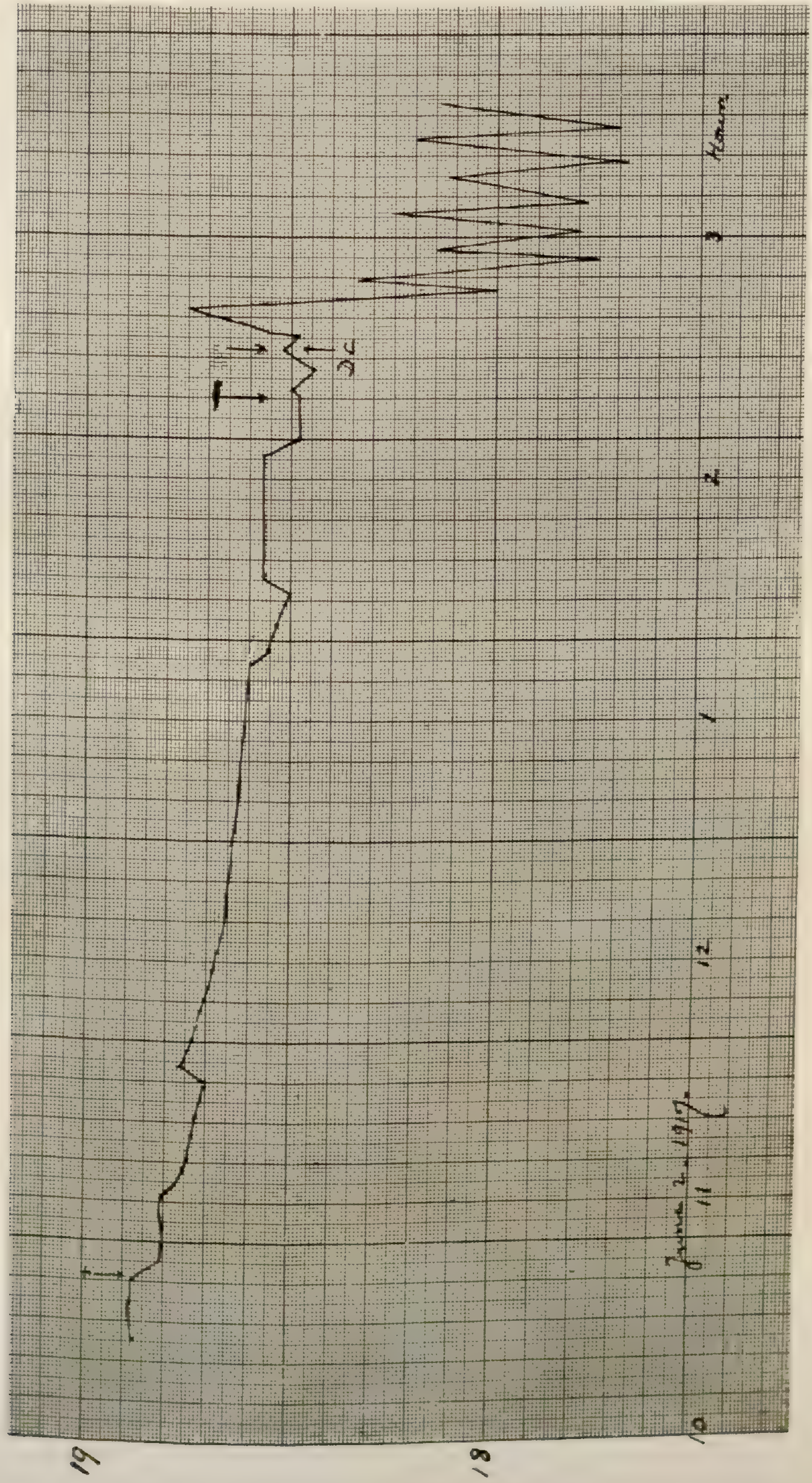
My thanks are due to the Carnegie Institution of Washington for meeting the expense of this work.

EXPLANATION OF PLATES.

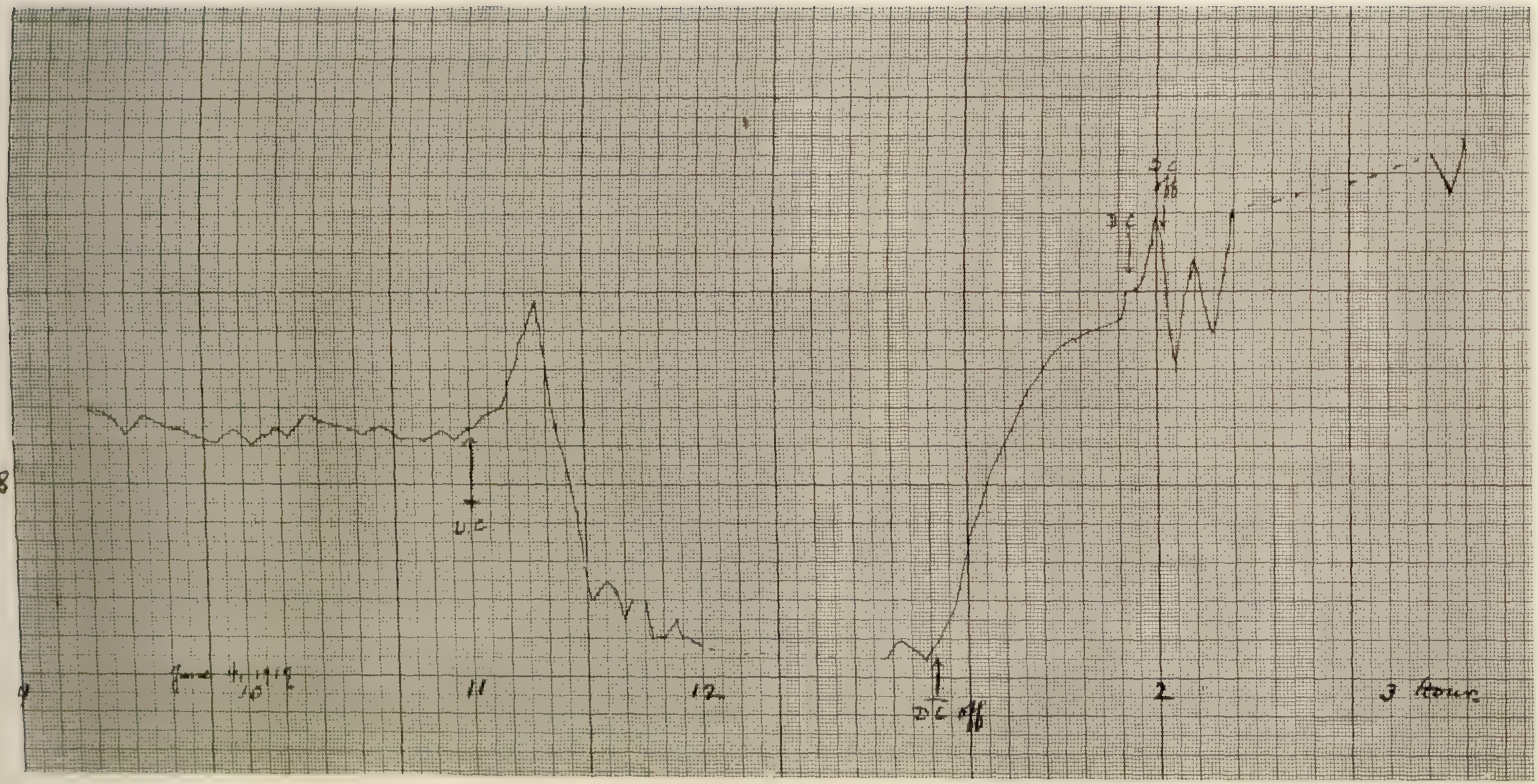
Plate XLV. Variation in Gravitational Attraction.
Plate XLVI. Variation in Gravitational Attraction.
Plate XLVII. Variation in Gravitational Attraction.

Issued November 8, 1917.


P. C.
Mean
Mean
Mean



VARIATION IN GRAVITATIONAL ATTRACTION



VARIATION IN GRAVITATIONAL ATTRACTION

Transactions of The Academy of Science of St. Louis.

VOL. XXIII. No. 6.

GRAPHICAL ALGEBRA INVOLVING FUNCTIONS OF THE Nth DEGREE.

FRANCIS E. NIPHER.

Issued May 9, 1918.

GRAPHICAL ALGEBRA INVOLVING FUNCTIONS OF THE n^{th} DEGREE.

FRANCIS E. NIPHER.*

In the study of algebra, there is a strong tendency among the young learners to follow rules, without giving serious attention to the fundamentals upon which rules are based. There are many graduates in algebra who could at once answer the question, What is the area of the square, whose sides are $x - a$. A diagram showing the original square, with the lengths a cut off from its sides would show that when the two strips $2xa$ have been subtracted from the area x^2, the area a^2 has been subtracted twice. Therefore the final term a^2 is properly added.

It often happens that a diagram suggests something which its symbolic representation does not suggest. When they are both presented, the suggestion is still more likely to come.

As is well known, the difference between the squares of two numbers y and x is

$$\begin{aligned} y^2 - x^2 &= (y - x)\ (y + x) \\ &= y\ (y - x) + x\ (y - x) \quad (1) \end{aligned}$$

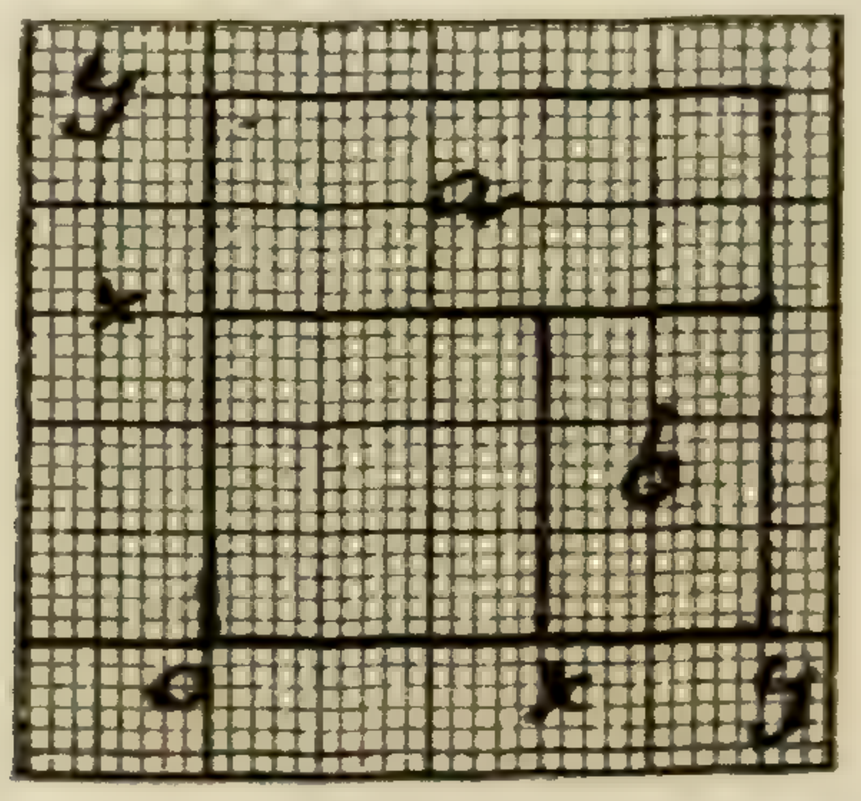


Fig. 1.

The two terms of the second member represent the areas of two rectangles marked a and b in Fig. 1. They have equal width $y - x$. Their lengths are y and x.

---

*Presented before The Academy of Science of St. Louis, March 18, 1918.

If we increase the lengths of the horizontal sides of these squares from y and x, to y^2 and x^2, the rectangles so resulting will have an area $y \times y^2 = y^3$, and $x \times x^2 = x^3$. In the diagram, Fig. 2, representing these rectangles the values of y and x have been assumed to be 5 and 3.

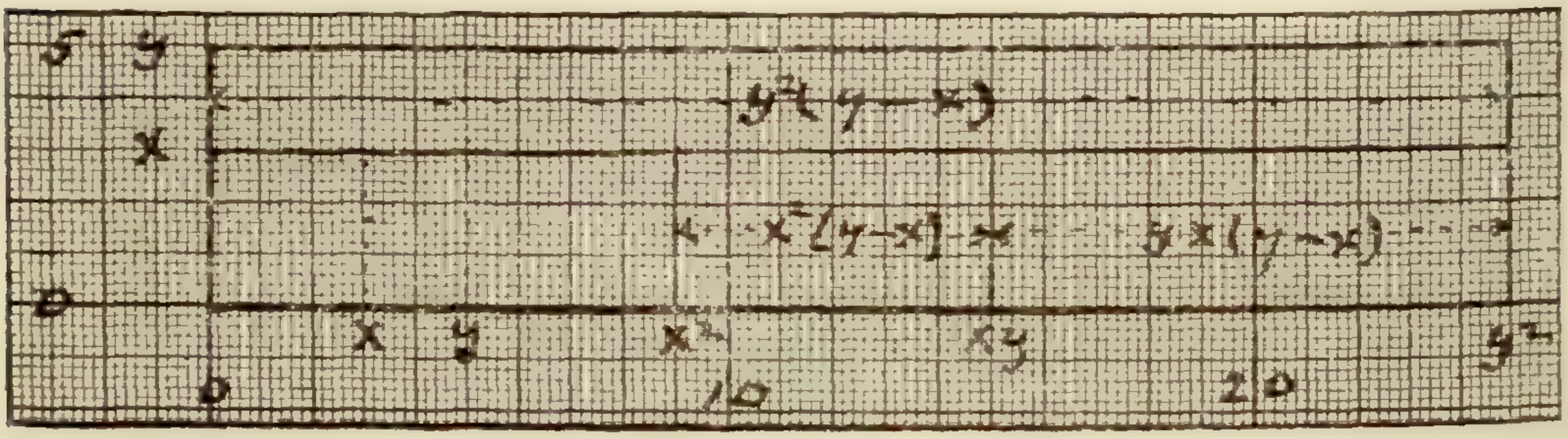


Fig. 2.

We may also describe these rectangles as being in the one case composed of five squares placed side by side, these squares each having an area of 5^2, and in the other of three squares each having an area of 3^2. We may also say that these rectangles represent values y^3 and x^3. The binominal $y^3 - x^3$ being divided by $y - x$ as in Eq. 1, we have when $y - x$ is multiplied into the terms of the quotient

$$y^3 - x^3 = y^2\ (y - x) + yx\ (y - x) + x^2\ (y - x) \quad (2)$$

The first term in the second member is represented by the area of the rectangle at the top of Fig. 2, whose length is y^2 and whose width is $y - x$. The second term is represented by the rectangle whose dimensions are x and $y^2 - yx = y\ (y - x)$. The final term has an area $x\ (yx - x^2) = x^2\ (y - x)$.[1]

Following a suggestion made by Professor Roever of the department of mathematics of Washington University, it may be pointed out that the construction of the diagram in Fig. 2 and in others that follow may be made by

[1] When one or two factors in a term represent an area, the remaining factors may be treated as multipliers. Thus $x^2\ (y - x)$ may be $2x^2$ in this case, or $x \times 2x$.

purely geometrical methods, without assuming any known values for x and y. If a straight line is drawn upon a sheet of paper, the square of which that line is a side, and the cube of which that square is to be a face, can be drawn, without any measurement of the length of the original line in terms of the centimeter or the inch.

Similarly if vertical and horizontal lines are drawn intersecting at a point which is to be common to the corners of two squares, having areas y^n and x^n we may mark upon these two axes points distant 1, x and y from the origin. These distances may have any length. The unit of length chosen may be any arbitrary and unknown length.

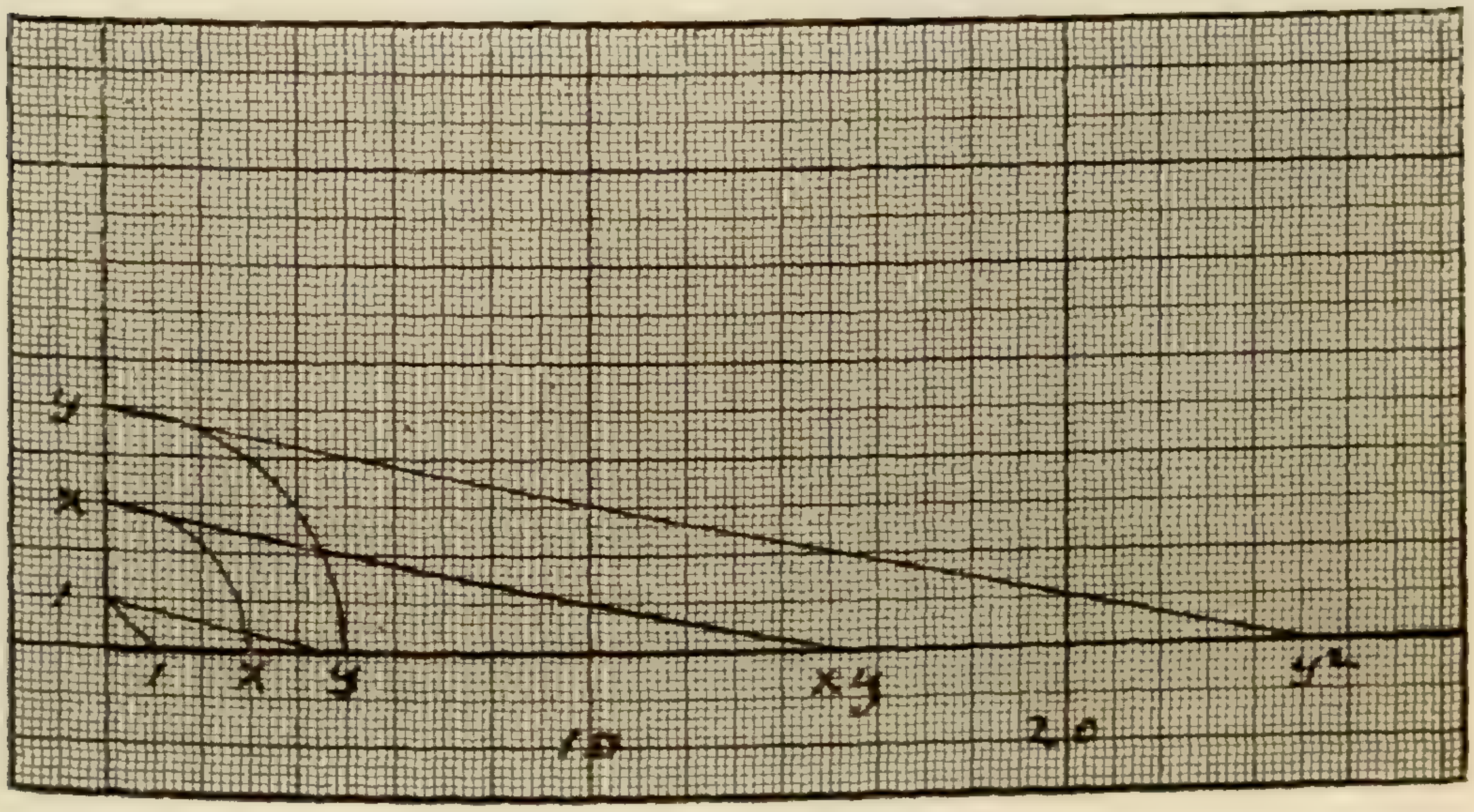


Fig. 3.

In Fig. 3 the unit when finally measured is found to be 0.5 cm. and x and y to be 1.5 and 2.5 cm.

Draw a line through the point marked 1 on the vertical axis, to the point marked y on the horizontal axis. Lines drawn parallel to this line through points marked x and y on the vertical axis, will pass through points distant xy and y^2 from the origin on the horizontal axis. These distances may then be laid off upon the vertical axis and the operation may be continued. All of the lengths in the preceding diagram can be thus laid off.

In Fig. 3 we find the lengths in centimeters to be

$$\begin{aligned} \text{Unit} &= 0.5 \text{ cm.} — 1.0 \\ x &= 1.5 \text{ cm.} — 3 \\ y &= 2.5 \text{ cm.} — 5 \\ xy &= 7.5 \text{ cm.} — 15 \\ y^2 &= 12.5 \text{ cm.} — 25 \end{aligned}$$

The lengths in terms of the chosen unit are given in the final column.

The distance x^2y may be laid off upon the axes, by drawing a line through the points marked 1 and xy. A line parallel to this through the point distant x on the vertical axis of the diagram, Fig. 3, will determine the point distant x^2y from the origin on the horizontal axis.

If we increase the width of the two rectangles y^3 and x^3 of Fig. 2 to y^2 and x^2, we shall have two squares whose areas are $y^2 \times y^2 = y^4$ and $x^2 \times x^2 = x^4$.

They are represented in Fig. 4. Figures 1 and 2 will also be identified in this diagram.

The difference between the areas of these two squares is

$$\begin{aligned} y^4 — x^4 &= (y^2 + x^2)\ (y^2 — x^2) \\ &= (y\ + x\ )\ (y^2 + x^2)\ (y — x) \\ &= y^3\ (y — x) + y^2x\ (y — x) \\ &\quad + yx^2\ (y — x) + x^3\ (y — x). \quad (3) \end{aligned}$$

The first two terms of the second member may be written

$$y^2\ (y^2 — yx) \text{ and } y^2\ (yx — x^2)$$

They are represented in Fig. 4 by the large rectangles a and b.

The two following terms of Eq. (3) may be written

$$x^2\ (y^2 — yx) \text{ and } x^2\ (yx — x^2)$$

They are represented by the rectangles marked c and d.

Figure 4 shows clearly the nature of the changes from the conditions in Fig. 1. When the sides of the two squares lying along the horizontal axis were increased to $y \times y$ and $x \times x$ as in Fig. 2, the rectangle a of Fig. 1 was

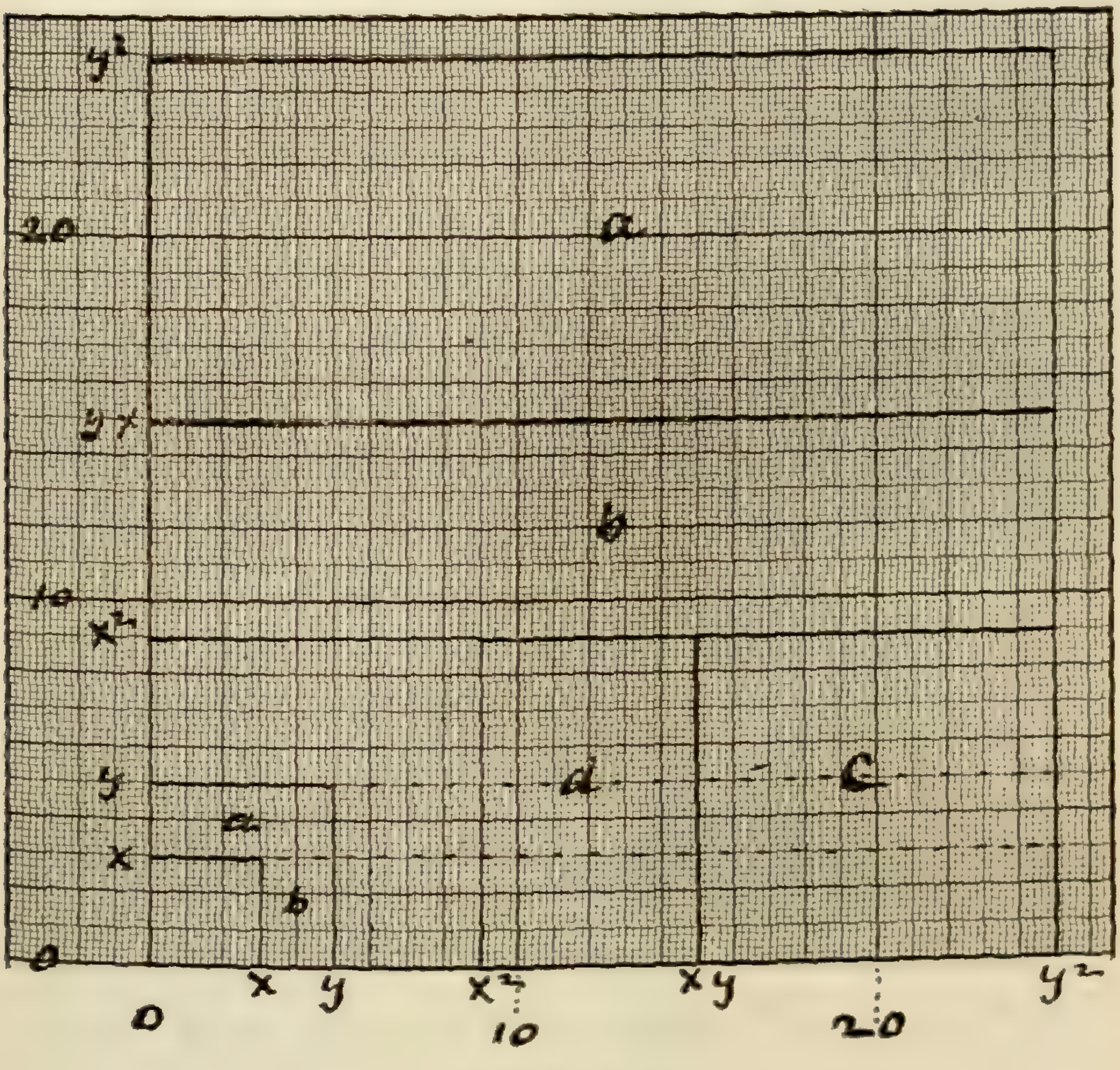


Fig. 4.

made longer and became $y \times y$ in length, but its width remained unchanged. It was still $y - x$. The rectangle b of Fig. 1 was replaced by two rectangles whose lengths were still x but in one of these rectangles, the width had increased from $y - x$ to $y^2 - yx = y\,(y - x)$ and in the other rectangle the width had increased from $y - x$ to $x\,(y - x) = xy - x^2$.

When the next change was made, from Fig. 2 to Fig. 4 the two rectangles to the right of $x \times x^2$ in Fig. 2 did not change in width but their length increased from x to

x^2. They become the rectangles c and d of Fig. 4. The narrow strip across the top of Fig. 2, shown between dotted lines in Fig. 4, was replaced by two strips marked a and b at the top of Fig. 4. Their length y^2 is the same as in Fig. 2. Their widths have increased from $y - x$ to $(y^2 - yx) = y(y - x)$ in one case and to $yx - x^2 = x(y - x)$ in the other.

These rectangles all decrease in width if x is made to approach y in value. When $x = y$ Eq. 3 shows that

$$\left(\frac{y^4 - x^4}{y - x}\right)_{x=y} = \frac{0}{0} = 4y^3 = \frac{\delta}{dy}(y^4)$$

This is the change in the area of y^4 per unit of change in y.

In Eq. (1) which is represented in Fig. 1, the values y and x which have been increased to y^2 and x^2 resulting in Eq. 2 and Fig. 2 are horizontal dimensions. This may be done by directly changing Eq. (1) to

$$y^3 - x^3 = y^2(y - x) + x(y^2 - x^2)$$

This is Eq. (2).

When the vertical dimensions y and x are changed to y^2 and x^2, the above equation becomes

$$y^4 - x^4 = y^2(y^2 - x^2) + x^2(y^2 - x^2)$$

This is one form of Eq. 3 and the resulting diagram is Fig. 4. It is of exactly the same structure as Fig. 1.

We may now increase the length of the sides of the rectangles y^3 and x^3 in Fig. 2 to y^5 and x^5, and y^4 and x^4, the values of y and x remaining unchanged.

Two rectangles having areas y^9 and x^9 are thus produced. They are shown in diagram, but not drawn to scale, in Fig. 5. If the centimeter is taken as the unit and $y = 5$ and $x = 3$ the rectangle y^9 would have sides $y^5 = 3125$ cm. and $y^4 = 625$ cm. if drawn to scale.

The difference between these areas y^9 and x^9 or $y^9 - x^9$ may be expressed by dividing by $y - x$, and multiplying this factor into the terms of the quotient.

$$y^9 - x^9 = y^8\,(y - x) + y^7\,x\,(y - x)$$
$$+ y^6\,x^2\,(y - x) + y^5\,x^3\,(y - x)$$
$$+ y^4\,x^4\,(y - x) + y^3\,x^5\,(y - x)$$
$$+ y^2\,x^6\,(y - x) + y\,x^7\,(y - x)$$
$$+ x^8\,(y - x) \ldots\ldots\ldots\ldots\ldots (4)$$

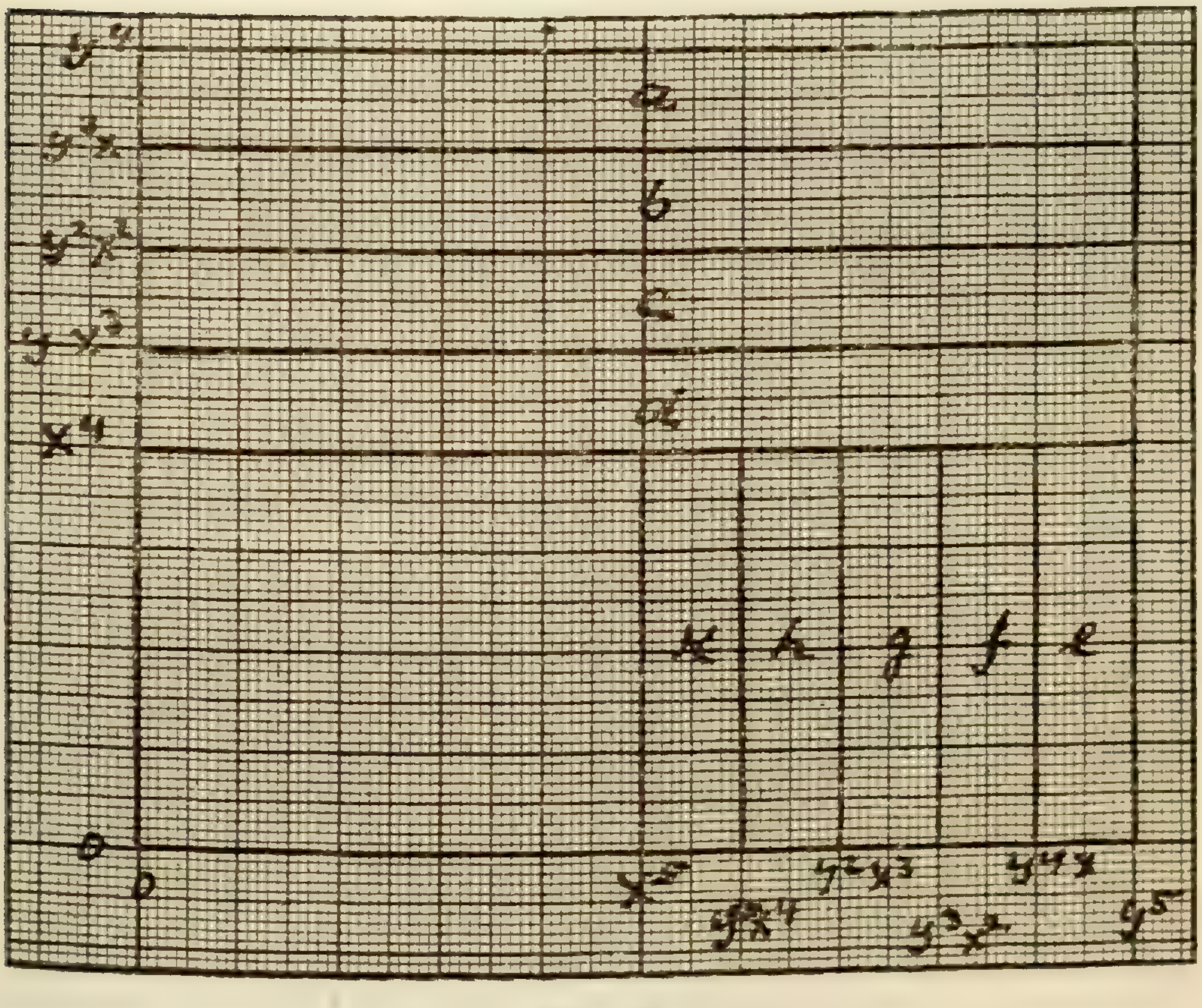


Fig. 5.

The first four terms may be written

$$y^5 \times y^3 \quad (y - x) \text{ or } y^5\,(y^4 \quad - y^3 x\,)$$
$$y^5 \times y^2 x\,(y - x) \text{ or } y^5\,(y^3 x - y^2 x^2)$$
$$y^5 \times y\,x^2 (y - x) \text{ or } y^5\,(y^2 x^2 - y\,x^3)$$
$$y^5 \times x^3 \quad (y - x) \text{ or } y^5\,(y\,x^3 - x^4)$$

These terms represent the areas of four rectangles, marked a, b, c and d in Fig. 5. They have a common length y^5.

The remaining five terms of Eq. (4) may be written

$$\begin{aligned}
x^4 \times y^4 \quad (y - x) \text{ or } & x^4 (y^5 \quad - y^4 x) \\
x^4 \times y^3 x \quad (y - x) \text{ or } & x^4 (y^4 x \quad - y^3 x^2) \\
x^4 \times y^2 x^2 \; (y - x) \text{ or } & x^4 (y^3 x^2 - y^2 x^3) \\
x^4 \times y\, x^3 \; (y - x) \text{ or } & x^4 (y^2 x^3 - y\, x^4) \\
x^4 \times \quad x^4 \; (y - x) \text{ or } & x^4 (y\, x^4 - x^5)
\end{aligned}$$

These terms represent the five rectangles e, f, g, h, k of Fig. 5. They have a common length x^4.

If we now increase the shorter sides of these rectangles from y^4 and x^4 to y^5 and x^5, the difference between the areas of the two squares thus formed will be

$$\begin{aligned}
y^{10} - x^{10} = y^9 \quad & (y - x) + y^8 x \quad (y - x) \\
& + y^7 x^2 \; (y - x) + y^6 x^3 \; (y - x) \\
& + y^5 x^4 \; (y - x) + y^4 x^5 \; (y - x) \\
& + y^3 x^6 \; (y - x) + y^2 x^7 \; (y - x) \\
& + y\, x^8 \; (y - x) + \quad x^9 \; (y - x) \qquad (5)
\end{aligned}$$

The first five terms may be written

$$\begin{aligned}
y^5 \times y^4 \quad (y - x) = y^5 \; & (y^5 \quad - y^4 x) \\
y^5 \times y^3 x \quad (y - x) = y^5 \; & (y^4 x \quad - y^3 x^2) \\
y^5 \times y^2 x^2 \; (y - x) = y^5 \; & (y^3 x^2 - y^2 x^3) \\
y^5 \times y\, x^3 \; (y - x) = y^5 \; & (y^2 x^3 - y\, x^4) \\
y^5 \times \quad x^4 \; (y - x) = y^5 \; & (y\, x^4 - \quad x^5)
\end{aligned}$$

The four rectangles a, b, c and d of Fig. 5, have been replaced by five, their lengths being y^5 as in Fig. 5. Their widths are now the same as the widths of the five rectangles e, f, g, h, and k in Fig. 5. The widths of the four rectangles a, b, c and d have all been multiplied by y and the last one above represented has been added.

The remaining five terms of Eq. 5 may be written

$$\begin{aligned}
x^5 \times y^4 \quad (y - x) = x^5 \; & (y^5 \quad - y^4 x) \\
x^5 \times y^3 x \quad (y - x) = x^5 \; & (y^4 x \quad - y^3 x^2) \\
x^5 \times y^2 x^2 \; (y - x) = x^5 \; & (y^3 x^2 - y^2 x^3) \\
x^5 \times y\, x^3 \; (y - x) = x^5 \; & (y^2 x^3 - y\, x^4) \\
x^5 \times \quad x^4 \; (y - x) = x^5 \; & (y\, x^4 - \quad x^5)
\end{aligned}$$

The width of these rectangles e, f, g, h and k remain as before, but their length has been made x times greater.[2]

In an arithmetic published by Dr. Daniel Adams, of Keene, N. H., in 1848, and which caused me much trouble in my youthful days, he gives a drawing of a cube, the length of the edges being 3 units. He then presents a drawing of 3^4, which he represents as three such cubes placed side by side. Then follows a drawing of 3^5, and 3^6, the latter being represented by 27 such cubes in the form of a cube whose edges are 3^2 in length. He gives a verbal description of the forms of such volumes up to "3^{18}, etc.," but he says not a word about space of 18 dimensions.[3]

All of the preceding discussion for quantities of the third degree or over, can be most interestingly presented by drawings in three dimensions. If y^3 and x^3 are represented as is usually done by cubical volumes, the geometrical significance of the three terms of Eq. 2 differs from that given in Fig. 2. It is unnecessary to explain them here.

If the lengths of x and y be increased to x^2 and y^2 we shall have two cubes whose volumes are y^6 and x^6. The difference in the volumes of these cubes will be,

$$y^6 - x^6 = y^5\,(y-x) + y^4x\,(y-x) + y^3x^2\,(y-x) + y^2x^3\,(y-x) + yx^4\,(y-x) + x^5(y-x) \quad (6)$$

The second member may be written

$$y^3\,[y^2\,(y-x) + yx\,(y-x) + x^2\,(y-x)]$$
$$x^3\,[y^2\,(y-x) + yx\,(y-x) + x^2\,(y-x)]$$

A reference to Eq. (2) will show that we have between the outer and inner cubes, two sets of rectangular volumes,

---

[2] The diagram representing Eq. 5 can be laid out upon a lawn. White twine attached to corner stakes may be used to mark boundary lines.

[3] As a matter of historical interest a reproduction of the page in which Dr. Adams gives this discussion, is reproduced at the close of this paper.

one set lying outside of the other. They are similar to those represented by the terms of Eq. (2). Each of the three dimensions of each block or volume in the outer layer has been made y times as long as in the volumes represented by the terms of Eq. (2). The similar dimensions of the inner layer have been multiplied by x.

A model of these cubes may be made as follows, assuming that $y = 5$ and $x = 3$.

The inner cube x^6 which is made of wood has dimensions $9 \times 9 \times 9$ cm. Its faces are each divided by lines into nine squares. Three blocks of wood are then to be applied to three adjoining sides. By the last three terms of Eq. (6) their dimensions are

$$\begin{aligned} xy \times xy \times x\,(y-x) &= 15 \times 15 \times 6, \\ xy \times x^2 \times x\,(y-x) &= 15 \times 9 \times 6, \\ x^2 \times x^2 \times x\,(y-x) &= 9 \times 9 \times 6. \end{aligned}$$

This forms a cube whose volume is

$$[x^2 + x\,(y-x)]^3 = (xy)^3 = (15)^3.$$

Outside of this a similar set of blocks is placed, represented by the first three terms of Eq. (6). The dimensions of these blocks are

$$\begin{aligned} y^2 \times y^2 \times y\,(y-x) &= 25 \times 25 \times 10, \\ y^2 \times yx \times y\,(y-x) &= 25 \times 15 \times 10, \\ yx \times yx \times y\,(y-x) &= 15 \times 15 \times 10. \end{aligned}$$

The result is a cube whose volume is

$$[x^2 + x\,(y-x) + y\,(y-x)]^3 = y^6.$$

The faces of the resulting cube should each be ruled into twenty-five equal squares, whose sides are $y = 5$.

Dr. Daniel Adams might have been more emphatic in his statements without going astray. "The 6*th*, 9*th*, 12*th*, 18*th*, etc., powers may be represented by cubes" and when so represented they have the same geometrical

significance as when the $3d$ power is so represented. Also any numerical value raised to any power, may be represented in space of two dimensions or as a straight line.

Eq. (6) may also be represented by a diagram analogous to that in Fig. 4. There will be three strip areas across the top of the square x^6, instead of the two areas a and b. Their common length is y^3. There will be three rectangles replacing c and d of Fig. 4, the height of each being x^3. The width of these strips can be found by dividing these factors into the terms of Eq. 6.

All of the terms of the developed function $y^n - x^n$ can be identified in a diagram, in which y and x are laid off on the vertical axis, and y^{n-1} and x^{n-1} are laid off along the horizontal axis. The strip a of Fig. 1 will increase in length as n increases, but its width $y - x$ will remain constant. It will be represented by the first term. Below this strip, will be a series of rectangles having a common height x. They will represent the second and succeeding terms of the developed function.

The value of $(y+x)^4$ may be represented by an area. Assume for example $y=5$ and $x=3$. Construct a square whose sides are $(y+x)^2=64$. Divide the sides into segments whose lengths are $y^2=25$, $2xy=30$ and $x^2=9$. Draw lines across the square through the points separating these segments. The square $(y+x)^4$ will then be divided into nine rectangles, representing the six terms of the expanded binominal $(y+x)^4$. If x be considered negative, some of these rectangles must be considered negative in value. Their location in the square will be a matter of interest to the young experimenter. If in addition $y=x$, the sum of the positive and negative areas will be equal.

Issued May 9, 1918

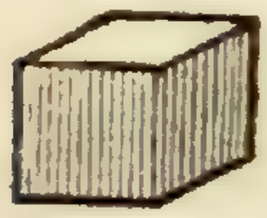
INVOLUTION.

First power. — *Second power.* □ *Third power.*

¶ 206. Three feet in length (¶ 111) are a yard, linear measure; 3 in length and 3 in width, $3 \times 3 = 9$ square feet, are a yard, square measure; 3 in length, 3 in width, and 3 in hight, $3 \times 3 \times 3 = 27$ solid feet, are a yard, cubic measure, (¶113.)

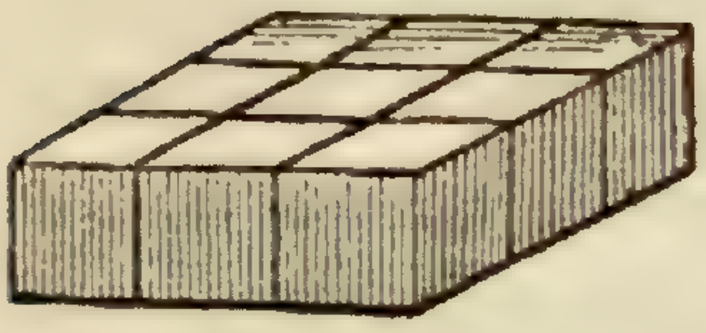
When a number, as 3, is multiplied into itself, and the product by the original number, and so on, the several numbers produced are called *powers*, and the process of producing them is called *Involution*.

The first number, represented by a line, is called the first power, or *root;* the second, represented by a square, is called the square, or 2d power; the third, represented by a cube, is called the cube, or 3d power.

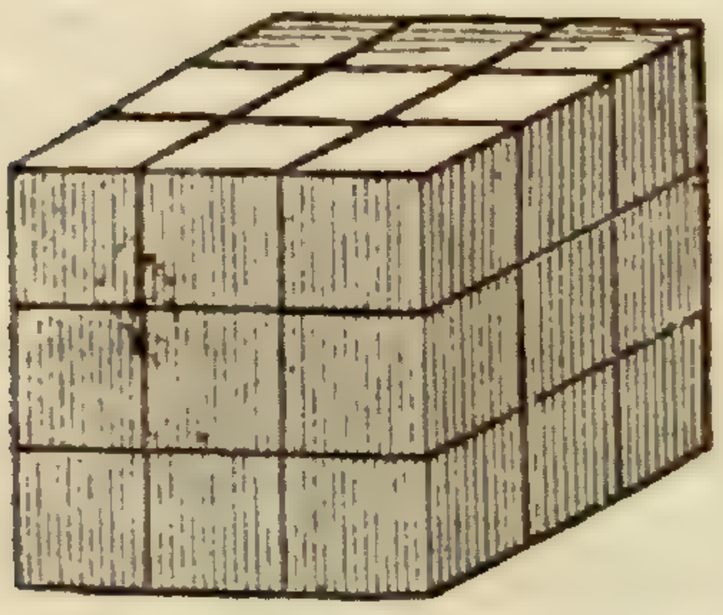


Fourth power.

Fifth power.



Sixth power.



The 4th power of 3 is 3 times the 3d power, 3 blocks like that employed to represent the 3d power, and may be represented by a figure 3 times as large, that is, 3 feet wide, 3 feet high, and 9 feet long.

The 5th power, by 3 times such a figure, or one 3 high, 9 wide, and 9 long.

The 6th power, 3 times this, by a figure 9 long, 9 wide, and 9 high, or a cube.

Thus it may be shown that the 9th, 12th, 15th, 18th, &c., powers, may be represented by cubes; the 7th, 10th, 13th, 16th, &c., by figures having greater length than width and hight; the 8th, 11th 14th, 17th, &c., by figures having greater length and width than hight.

To involve a number, take it as a factor as many times as is indicated by the required power.

NOTE. 1 — The number denoting the power is called the *index*, or *exponent;* thus, 5^4 denotes that 5 is raised or involved to the 4th power.

(From Adams' Arithmetic—See p. 201.)

Transactions of The Academy of Science of St. Louis.

VOL. XXIII. No. 7.

GRAPHICAL ALGEBRA

FRANCIS E. NIPHER.

Issued January 23, 1919.

GRAPHICAL ALGEBRA.*

FRANCIS E. NIPHER.

In the former paper it was shown that algebraic functions of a higher order than the second degree may be represented in diagram upon a plane surface.

In the present paper the same function will be represented by widely different diagrams.

The difference between the areas of two squares having sides the length of which are y^5 and x^5 is

$$\begin{aligned} y^{10} - x^{10} = {} & y^9 \quad (y - x) + y^8x \ (y - x) \\ & + y^7x^2 \ (y - x) + y^6x^3 \ (y - x) \\ & + y^5x^4 \ (y - x) + y^4x^5 \ (y - x) \\ & + y^3x^6 \ (y - x) + y^2x^7 \ (y - x) \\ & + y \ x^8 \ (y - x) + x^9 \quad (y - x) \end{aligned} \tag{5}$$

This is Eq. (5) of the former paper.

This equation may be written:

$$\begin{aligned} y^{10} - x^{10} = {} & y^5 \quad (y^5 \quad - y^4x \ ) + y^4x \ (y^5 \quad - y^4x \ ) \\ & + y^4x \ (y^4x \ - y^3x^2 \ ) + y^3x^2 \ (y^4x \ - y^3x^2) \\ & + y^3x^2 \ (y^3x^2 - y^2x^3) + y^2x^3 \ (y^3x^2 - y^2x^3) \\ & + y^2x^3 \ (y^2x^3 - y \ x^4) + y \ x^4 \ (y^2x^3 - y \ x^4) \\ & + y \ x^4 \ (y \ x^4 - \quad x^5) + \quad x^5 \ (y \ x^4 - \quad x^5) \end{aligned} \tag{7}$$

$$\begin{aligned} = {} & (y^5 \quad + y^4x \ ) \ (y^5 \quad - y^4x \ ) \\ & + (y^4x \ + y^3x^2) \ (y^4x \ - y^3x^2) \\ & + (y^3x^2 + y^2x^3) \ (y^3x^2 - y^2x^3) \\ & + (y^2x^3 + y \ x^4) \ (y^2x^3 - y \ x^4) \\ & + (y \ x^4 + \quad x^5) \ (y \ x^4 - \quad x^5) \end{aligned} \tag{7a}$$

$$\begin{aligned} = {} & (y^{10} \quad - y^8x^2) + (y^8x^2 - y^6x^4) \\ & + (y^6x^4 - y^4x^6) + (y^4x^6 - y^2x^8) \\ & + (y^2x^8 - x^{10}) \end{aligned}$$

---

* Continued from No. 6, Vol. XXIII. Presented by title before the Academy of Science of St. Louis, January 20, 1919.

This equation is represented in diagram in Fig. 1. The ten terms of Eq. (7) are represented by the areas of the rectangles marked with numerals 1 to 10.

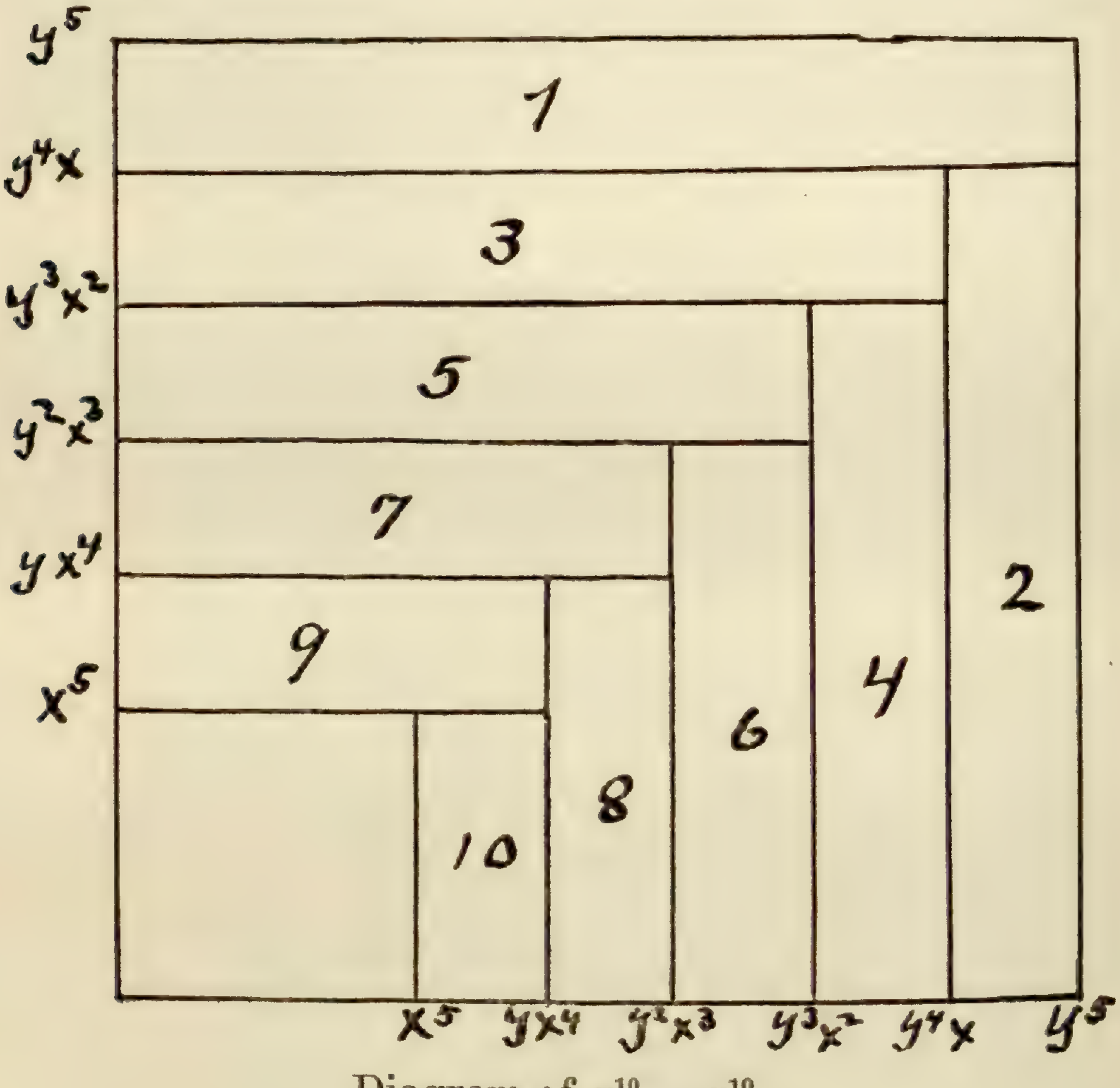


Diagram of $y^{10} - x^{10}$.

Fig. 1.

Any values may be assigned to x and y and this diagram may be drawn to scale if the assigned values are not too large, or do not differ too much from unity.

The computed values are of interest in some cases even if they cannot be laid off to scale. For example assume the values of y and x to be 5 and $\frac{1}{4}$, the unit of length being the inch. The squares y^2 and x^2 would then have sides the length of which would be 5 inches and $\frac{1}{4}$ inch.

Multiplying these sides by y^4 and x^4 the sides of the resulting squares would have lengths $y^5 = 3125$ inches

and $x^5 = 0.000976$ inch. This square would hardly be visible to the unaided eye. The width of the two strips marked 1 and 2 in Fig. 1 would be $y^5 - y^4x = 3125 - 156.25 = 2968.75$ inches. Their combined length is $y^5 + y^4x = 3281.25$. The product of these two numbers would be the difference between the areas of the two squares, y^{10} and y^8x^2.

The width of the two areas which represent the ninth and tenth terms would be $yx^4 - x^5 = 0.01953 - 0.000976 = 0.01856$. Their combined length is $yx^4 + x^5 = 0.02050$. The product of these two quantities gives the difference between the two squares y^2x^8 and x^{10}.

This diagram and the final form given to Eq. (7) shows that Eq. (5) is similar to another well known equation

$$y^2 - x^2 = y\,(y - x) + x\,(y - x).$$

Equation (5) may be written:

$$\begin{aligned} y^{10} - x^{10} = {} & y^5\,(y^5 - y^4x) + y^5\,(y^4x - y^3x^2) \\ & + y^5\,(y^3x^2 - y^2x^3) + y^5\,(y^2x^3 - yx^4) \\ & + y^5\,(yx^4 - x^5) + x^5\,(y^5 - y^4x) \\ & + x^5\,(y^4x - y^3x^2) + x^5\,(y^3x^2 - y^2x^3) \\ & + x^5\,(y^2x^3 - yx^4) + x^5\,(yx^4 - x^5) \end{aligned} \qquad (8)$$

In order to respond to this change the strips marked 3, 5, 7, and 9 must be extended to the right side of the square y^{10}, their widths remaining unchanged, when drawn to scale. They will then have a common length y^5. The first term in this equation is the same as in Eq. (7). The strips marked 2, 4, 6, and 8 must be correspondingly reduced in length to x^5, the strip marked 10 remaining unchanged. In this arrangement the strips marked 1, 3, 5, 7, and 9 will represent the first five terms in the equation, and those marked 2, 4, 6, 8, and 10 will represent the five final terms. As thus changed, the strip marked 9 would have an area $y^5\,(yx^4 - x^5)$. As drawn in the diagram the strip marked 5 has an area $y^3x^2\,(y^3x^2 - y^2x^3)$, which is equal to the area of strip 9 when thus extended.

The five horizontal strips when thus extended, may be considered as one strip, having an area $y^5\ (y^5 - x^5)$, and the area of the vertical strips is $x^5\ (y^5 - x^5)$. The sum of the two resulting strips is

$$y^{10} - x^{10} = y^5\ (y^5 - x^5) + x^5\ (y^5 - x^5).$$

Equation (3) is readily reduced to this form. It is entirely similar to the well-known equation

$$y^2 - x^2 = y\ (y - x) + x\ (y - x).$$

As was suggested in the former paper, the two squares y^2 and x^2 may be changed by applying the multiplying factor to the horizontal sides of the two squares. The areas remaining as in former equations, and adopting the same unit, and the same values for y and x, the area y^{10} would then be a rectangle, the vertical width of which would be $y = 5$ inches, and the horizontal side would have a length $y^9 = 1{,}593{,}125$ inches or 30.8 miles. The rectangle x^{10} would have a vertical dimension $x = 1/4$ inch, and the horizontal dimension would be $x^9 = 0.000{,}003{,}81$ inch.

In order to adjust Eq. (5) to this change, it must be written,

$$\begin{aligned} y^{10} - x^{10} = {} & y^9\ (y - x) + x\ (y^9 - y^8 x) \\ & + x\ (y^8 x - y^7 x^2) + x\ (y^7 x^2 - y^6 x^3) \\ & + x\ (y^6 x^3 - y^5 x^4) + x\ (y^5 x^4 - y^4 x^5) \\ & + x\ (y^4 x^5 - y^3 x^6) + x\ (y^3 x^6 - y^2 x^7) \\ & + x\ (y^2 x^7 - y x^8) + x\ (y^8 - x^9) \end{aligned}$$

The five horizontal strip areas of the diagram are now replaced by one, the width of which is $y - x = 4.75$ inches and the length $y^9 = 1{,}593{,}125$ inches or 30.8 miles. The remaining terms are represented by a series of rectangles having a common height $x = 1/4$ inch, and filling the space $x\ (y^9 - x^9) = 1/4\ \ (1{,}593{,}125 - 0.000{,}003{,}81)$ square inches.

In planning a diagram involving squares y^4 and x^4, $1/y^4$, $1/x^4$ upon a sheet of paper having an ordinary size the lengths y^2 and $1/y^2$ may be laid off upon the two axes as may be suitable to the size of the paper. If y^2 is about 15 or 16 inches and $1/y^2$ is to be not less than one inch, the length which the unit of length must have may be determined by purely geometrical means. Draw parallel lines through the points marked y^2 on one axis and $1/y^2$ on the other axis, which cross the two axes at points equidistant from the origin. Since

$$\frac{1/y^2}{1} = \frac{1}{y^2}$$

these points will be at unit distance from the origin. If the above values of $1/y^2$ and y^2 are adopted, the unit of length thus assumed will be not far from 3¾ or 4 inches.

In terms of this unit y^2 will be about 4 units in length. The value of y in terms of this unit may be determined in a similar manner, since $1/y = y/y^2$. By this method of similar triangles the lengths $\sqrt{y}$, $1/\sqrt{y}$ and $1/y$ may be determined, all values being laid off on both axes.

The length x may then be assumed to be about midway between 1 and y. Then the lengths xy, x^2, $\sqrt{xy}$, y/x, $\sqrt{x}$, x/y, $1/x$, $1/\sqrt{xy}$, $1/x^2$ and $1/xy$ can be similarly determined by graphical methods, and laid off on both axes.

If cross-lines are now drawn through points so determined extending across the square y^4, an interesting collection of squares and rectangles will be produced. Within the square y^4 eight hyperbolae may be drawn, passing through the corners of these squares and rectangles. The points on the various curves which are so determined range from three to thirteen. The constants of these hyperbolae are y^2x^2, y^2, yx, x^2, y, x, 1, and x^2/y^2.

The difference between the areas of the two squares having sides whose lengths are $\sqrt{y}$ and $\sqrt{x}$ is

$$y - x = \sqrt{y}\ (\sqrt{y} - \sqrt{x}) + \sqrt{x}\ \ (\sqrt{y} - \sqrt{x}).$$

Fig. 2 is a triangle of terms needed in the construction of any diagram similar to that forming Fig. 1, for the function $y^n - x^n$, between the limits $n = 2$ and $n = 20$.

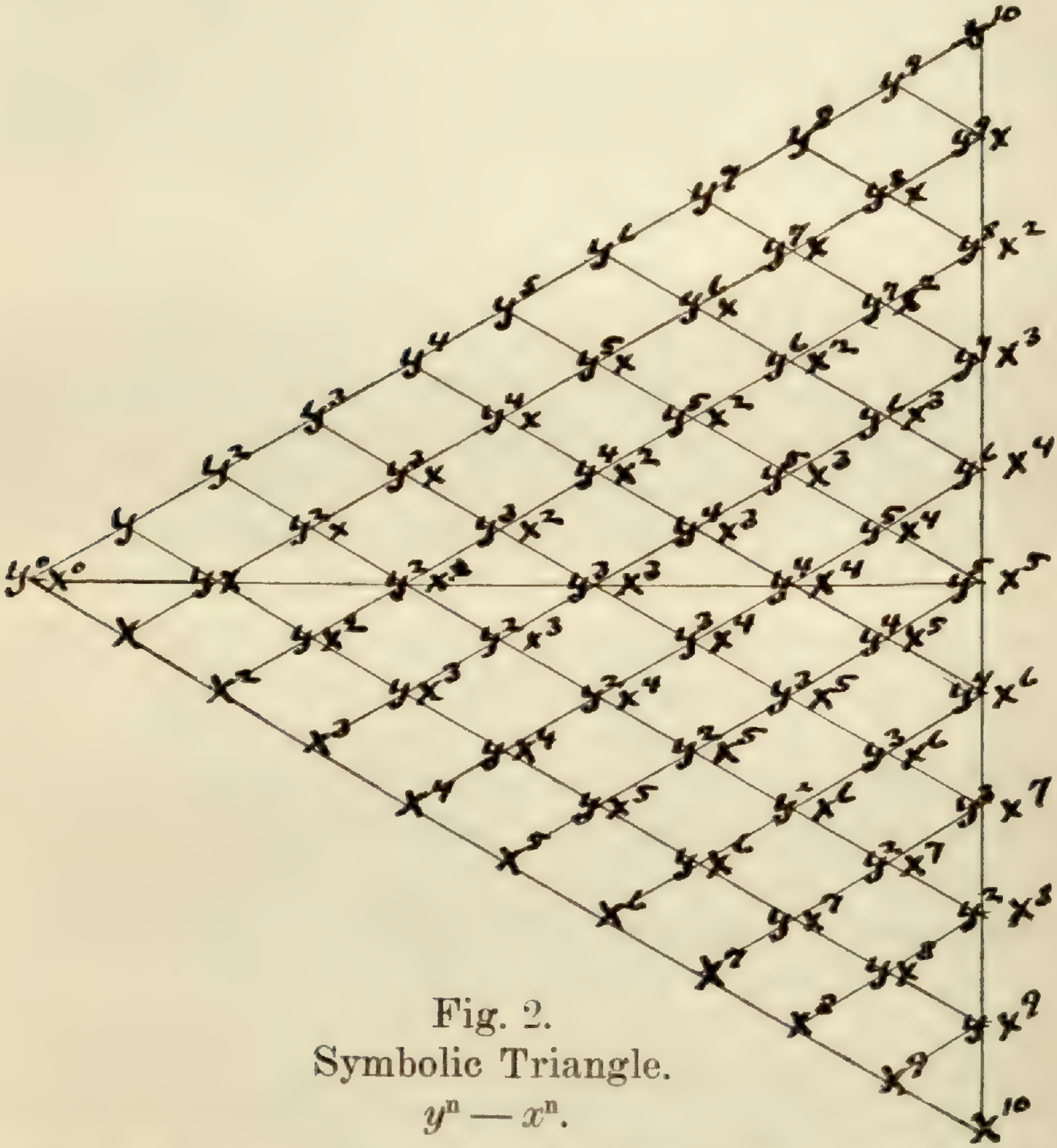


Fig. 2.
Symbolic Triangle.
$y^n - x^n$.

In the left vertical column are the lengths y and x. The difference between these two lengths, is the width of the strips between the two squares y^2 and x^2. The sum of these terms is the combined length of the two strips. The product $(y - x)\ (y + x)$ gives the value $y^2 - x^2$. These symbols may represent any value greater than zero. The distance between any two points in space cannot be less than zero. In the equation last above written they are replaced by $\sqrt{y}$ and $\sqrt{x}$. These symbols probably belong to the left of y and x in Fig. 2, approaching nearer to the apex of the triangle.

In the vertical column having y^5 and x^5 at its extremities, are the terms involved in the construction of the diagram forming Fig. 1, and representing $y^{10} - x^{10}$. The difference between the two terms y^5 and y^4x, multiplied by their sum, gives the area of the two strips marked 1 and 2 in Fig. 1. It represents the difference between the areas of the two squares y^{10} and y^8x. Similarly $(y^4x - y^3x^2)$ $(y^4x + y^3x^2)$ gives the areas of the two strips marked 3 and 4 in Fig. 1. This vertical column is a reproduction of the series of values along the co-ordinate axes in Fig. 1. The vertical column to the left contains the terms obtained by dividing $y^5 - x^5$ by $y - x$. Starting with any term in the triangle, successive terms along the line leading upwards to the right are obtained by multiplying by y. Along a horizontal line the factor is xy. Along a line leading downwards to the right the factor is x. Along a line leading vertically downwards the factor is x/y. Throughout this triangle we find the conditions which exist around the small quadrangle forming its apex where (y^0x^0) $(yx) = y \times x$. The square of any term is equal to the product of any two terms similarly placed with respect to it, along either of the eight lines of terms diverging from it.

The methods here outlined have been in use in the physics laboratory of Washington University for forty-four years. The student who knew nothing of analytical geometry was made familiar with the curves represented by the equations $y = x^n$ *and* $y = a\,x^n$. Curves were drawn for values of n of 3, 2, 1, ½, 0, — ½, — 1, and — 2. When familiar with the forms of these curves, he would be asked to "discover" by experimental methods such laws as that for the simple pendulum. The form of the curve obtained by plotting the observed values of l and t made it seem probable that the relation was represented by the equation $l = a\,t^2$. When the lines representing the values t were elongated until their length was $t \times t$, if the points so determined were in a straight line, the probability became a certainty. The conclusion is that the length of

the pendulum is directly proportional to a time interval which is t times as great as the time interval t of one vibration. It does not follow that a time interval may be squared, or that there is such a unit as a square second.

Many times a class of 50 or 60 pupils who had been with us but a few months, have been given data representing the times of rotation of planets around the sun and their mean distances from the sun, with the request that they find the relation between these quantities. In every case more than nine-tenths of the class would "discover" Kepler's third law within twenty-four hours. The plotted values made it certain that n was greater than 1. The result was a curve which made it seem probable that $t = a\, r^2$. When the values of r were squared and t and r^2 were plotted, the result was a curve which bent in the opposite direction. Therefore n must be less than 2 and greater than 1. When it was assumed that n was 3/2 or that $t^2 = a\, r^3$ and these values t^2 and r^3 were plotted, the result was a straight line.

The young discoverers were always greatly interested to learn that Kepler struggled with this problem for seventeen years after he was in possession of the data which they had received, before he discovered the relation between these variables. Of course after students have become familiar with logarithms, and they wish to find the value of n in the equation $y = a\, x^n$, the equation may be written

$$log\ y = log\ a + n\ log\ x.$$

When $log\ y$ and $log\ x$ are plotted as co-ordinates, a stranght line will be obtained whatever the value of n may be if the above equation holds. The slope of that line is the value of n. This method of instruction is far better than the one which requires the student to test the equation given in his text-book. The student should be put in possession of methods which enable him to discover laws, even if he is not the first to discover them.

Issued January 23, 1919.

Transactions of The Academy of Science of St. Louis.

VOL. XXIII. No. 8.

BIRDS OF THE KANSAS CITY REGION.

HARRY HARRIS.

Issued February 27, 1919.

INTRODUCTION.

The following list of birds contains those species which have been noted in the vicinity of Kansas City, Missouri. Most of the birds listed have been seen in Jackson County, Missouri, but the ground covered by the list includes Clay and Platte Counties, Missouri, and Johnson County, Kansas. The extreme limits of the region covered by the notes used in the preparation of the list are Warrensburg, Missouri, Johnson County, forty-seven miles (as the Crow flies) from Kansas City, Corning, Missouri, Holt County, ninety-four miles from Kansas City, and Douglas County, Kansas, twenty-eight miles from Kansas City.

Kansas City itself is on the Missouri River, at its junction with the Kansas, or Kaw River, in Lat. 39, Long. 94 30'. The Missouri River makes a sharp turn to the east here. It is bordered on the south by bluffs of loess and cliffs of limestone which rise to a height of more than 250 feet above the river. On the north, in Clay County, there is a broad flood plain, bordered at some distance from the river by cliffs. These alternations of bluff, cliff, sand bar and flood plain are characteristic of the Missouri River throughout its course in the region above defined. Where small streams find their way to the river, a "draw" winds for a short distance back of the bluffs. The bluffs and the "draws" are richly clothed with pawpaw and red bud, wild grape and black maple, the haunts of the Cardinal and the Carolina Wren.

Where small rivers, such as the Big and Little Blue, have cut a valley to the Missouri from the higher prairies, they duplicate in miniature the features characteristic of the great river; narrow bottom lands fringe one side, and cliffs the other, alternating as the streams wind. The rich soil along the rivers is shaded by great elms, tall hackberries and "Cochi" beans (Kentucky Coffee trees); the base of the cliffs are covered with bladder-nut and cornel. Here the Kentucky Warbler, the Tufted Tit and the Red-bellied Woodpecker are characteristic birds.

Above the cliffs there are thin-soiled shelves of limestone,

covered in summer and fall with a profusion of bright flowers, nigger-heads, asters, goldenrod and blazing star. If these so-called barrens are extensive, they are covered with thickets of plum, wild crab and buckthorn, the favorite home of Bell's Vireo. Where the soil becomes deeper and the prairie begins, man has for the most part taken possession, and turned the stiff prairie grass under, and is now raising wheat, clover, alfalfa and grass. The Prairie Horned Lark, the Mourning Dove, and the Dickcissel are the birds of the wheat fields. On the farmsteads themselves and in the windbreaks of soft maple that surround them, breed the birds which the farmer boy knows best. the Wren, the Kingbird, the Purple Martin, the Bluebird, and the rest of the well known list. In the osage orange hedges that divide the upland fields, Shrikes nest and many migrant birds find shelter.

The river, as it sweeps past on its way to the Gulf, has offered for untold centuries a highway for the many species that breed in northern latitudes. The House Wrens and Orchard Orioles of Nebraska rest in early May in the willows along its bars, the Purple Finches and Siskins on their way south in the fall, feed on the "buttons" of the sycamores. But to the real river-man, who has watched for many years the floods make and remake the ever-shifting shores, the flight of birds suggests the great waves of ducks and geese that rest on the sandbars, or in the swift current itself, or the "Snipe," the Sandpipers or Plover that feed on the exposed flats or wheel with shrill pipings over the muddy water. With these birds are associated all the other waterfowl less important to the sportsman, but often coming within his ken, the majestic Pelican, the Grebe, the Coot and the Herons.

The city itself has destroyed many former breeding places of the birds, but in the residence section the planting of trees and shrubs has attracted those species that adapt themselves to the neighborhood of man. The Brown Thrashers and Catbirds nest in the shrubbery, Orioles and Robins in the elms, Bluebirds, Wrens and Martins in the boxes now so generally put up. The Chimney Swift is still seen over the mass of stone and concrete that covers the downtown section of the city.

During migration many of the smaller birds pass through the tree tops in the residence sections of the city, or hide by day in

the shrubbery of the yards. In any open space, such as Penn Valley Park, Mount Washington or Forest Hill Cemetery, a large number of migrants may be found. Swope Park is so extensive and so varied in character that almost every bird belonging to the Kansas City region may be found there either breeding, wintering or passing through. A census of the birds in Swope Park, made by Mr. A. E. Shirling, includes 150 species, of which 73 species, represented by 2,025 singing males, bred within the borders of the Park.

The region about Kansas City probably compares favorably with any section of the country in the number of birds that are found at different seasons of the year. In only one respect is the region unfavorable for certain groups of birds; it lacks extensive marshes or reedy lakes where Rails, Marsh Wrens and Bitterns could find the shelter in which they breed. There are a few places, chiefly near the Missouri River, where such birds have been found. In Platte County the shallow river-lakes, such as Bean Lake, and Sugar and Mud Lakes at Armour, are covered in part with a growth of cat-tails. Here Gallinules, Least Bitterns, Black Terns and Yellow-headed Blackbirds are fairly common.

The increase of ducks and geese, since the passage of the Federal Migratory Bird Law, has been noticeable. More ducks have passed through, and, in many localities, several species are remaining to breed, which formerly were driven off by spring shooting.

The larger birds, those which were hunted, and the birds of prey which depend on the game birds for food and were themselves a mark for gunners, have diminished to a deplorable extent. All the earlier naturalists noted the abundance of waterfowl along the Missouri, and of game birds on its banks. Canada Geese nested in the Missouri bottoms in the days of Audubon, Wild Turkey and Prairie Chicken were everywhere common. Eagles and Fish Hawks built bulky nests in the tall trees in the bottom lands; Duck Hawks and Ravens had their homes in the cliffs.

Several species once plentiful or even abundant are now extinct, either in the whole country, or in the region covered by this list. The Passenger Pigeon and the Paroquet have van-

ished everywhere; the Ivory-billed Woodpecker and the Ruffed Grouse are gone from Western Missouri.

On the other hand, some birds have probably increased with the cutting off of the timber and the cultivation of the fields. There are probably more Dickcissels and Prairie Horned Larks, more Shrikes and Bluebirds now than fifty years ago. Their enemies have decreased and the land suitable for breeding has grown more extensive.

Very little has been previously published about the birds of Western Missouri. The following references form as complete a bibliography as the author has been able to compile:

On June 25, 1804, the Lewis and Clark Expedition encamped for the night on an island in the Missouri River near the mouth of a large creek called the Blue-water (now known as Big Blue River) and on the next evening had reached a point at the confluence of the Kansas (Kaw) where they remained for two days. Here they secured game in plenty, including Deer and Wild Turkey. On their return they passed this point on September 15, 1806, and killed an Elk and saw many Wild Turkeys.

Thomas Say, of the Long Expedition, made an excursion across Jackson County from Fort Osage (Sibley) to the Konza River (Kaw), leaving the fort on August 6, 1819, and rejoining the main party on the Missouri, near the mouth of the Platte, about September 1. He mentions the abundance of game and states that here Ravens were first seen by the party. He adds that in this region he saw a pretty species of Sparrow that was altogether new to him. Reference is here made to the Lark Sparrow which the party had discovered a short time before further down the Missouri River at Bellefontaine.

In the spring of 1834, Thomas Nuttall in company with Jno. K. Townsend passed through Jackson County on the old Independence-Westport Road on his way to the Pacific Coast. Mention of this stage of the journey is made in the second edition of his "Manual," published in 1840, where the Mourning Finch (now known as Harris's Sparrow) is described and the type locality given as "a few miles west of Independence."

Maximilian, Prince of Wied, had ascended the Missouri River in 1833, and on his return the next spring, just 17 days after Nuttall and Townsend had left Independence, he dis-

covered, near the mouth of Platte River, a finch new to him which he named Fringilla comata. He minutely described this bird (the Mourning Finch of Nuttall) in the second volume of his journal published in 1841.

Audubon, who reached this point on May 2, 1843, on his journey up the Missouri River to Fort Union, speaks in his journal of the abundance of Wild Turkeys and Paroquets, and gives a list of 49 species of birds observed or collected. This list contains such locally extinct or rare birds as Ruffed Grouse, Duck Hawk, Swan, Bald Eagle (two nests). In the bottom land on the Missouri side, near Leavenworth, his party took specimens of the sparrow which he named after his friend Edward Harris, not knowing of the discovery of this bird in 1834 by Nuttall. At this point was discovered a vireo, new to science, which Audubon named after another member of the party—J. G. Bell.

On the return, in 1843, four Paroquets and two Ruffed Grouse were killed in the vicinity of St. Joseph, and near Leavenworth great flocks of migrating Geese and Pelicans were seen on October 10th. Three days later a great number of Sandhill Cranes were seen.

Edward Harris, who accompanied Audubon, and for whom the supposedly new finch was named, published a list of 118 species seen between Fort Leavenworth and Fort Union (5th Annual Report Smithsonian Institution, for 1850).

Of the birds noted by Dr. P. R. Hoy in this vicinity in 1854, at least one species, the Purple Sandpiper, has not since been observed (19th Annual Report Smithsonian Institution, 1864).

Dr. J. A. Allen collected a series of specimens in May, 1871, in the bottoms of Platte County, and took several species of water-birds about a lagoon, probably Horseshoe Lake. (Bull. Museum Comparative Zool., 1872).

W. E. D. Scott, who was employed at the Normal School of Warrensburg, Johnson County, during the spring of 1874, published a list of 147 species observed and collected in that vicinity (Nuttall Bulletin, Vol. 4, 1879).

A few scattered field notes and short articles on rare and unexpected species, by local observers, have from time to time appeared in the bird journals. No previous attempt has been

made to give a complete local list, excepting of course the admirable state list of Mr. Otto Widmann. This list was published in 1907 by the St. Louis Academy of Science as Vol. XVII, No. 1, of their Transactions. The list is a monument to the accurate and full information which Mr. Widmann gathered together from his own widespread observation and from his correspondents throughout the state.

RALPH HOFFMANN

BIRDS OF THE KANSAS CITY REGION.

HARRY HARRIS.

PREFACE.

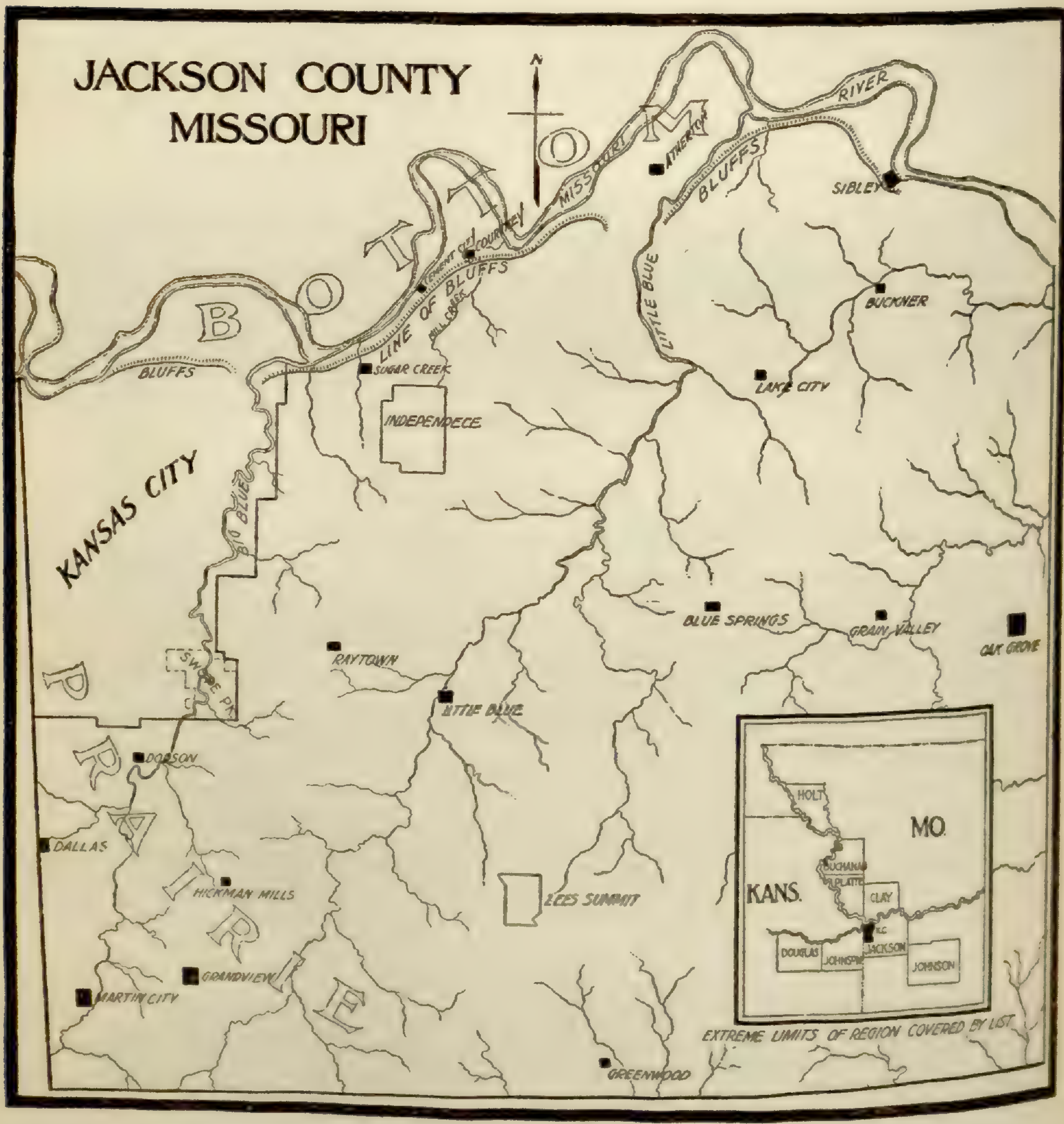
There has been no list of the birds of the Kansas City region which local students of birds could consult. It is hoped that the present summary of an extensive study of the avifauna of Jackson County, Missouri, and vicinity, will be of service to local nature-study classes, and to bird students in general. It is hoped also that it may stimulate that scientific interest in bird-study which is an active and powerful incentive to the growing movement for bird protection.

No attempt has been made to furnish a means of identifying birds, since so many standard works covering this ground are available. A list of desirable books is given in the text. The nomenclature used is that of the American Ornithologists' Union Check List.

The total number of species and subspecies listed is 343. This number includes 8 species that have become extinct in this region, and 17 that occur here only as wanderers out of their ranges. The summer residents—that is breeders—number 117, of which 12 are very rare. The 9 species and subspecies indicated in the text by brackets, have not yet been authenticated, but they should occur here and are included to call the attention of local students to the possibility of establishing their presence in this vicinity.

Credit is due several local ornithologists for the generous loan of notes and material which have greatly aided in the working out of migration periods and in authenticating the occurrence of a few rare species. These courtesies are here acknowledged with thanks. The greatest stimulus to the work has been the field-companionship of Mr. Ralph Hoffmann. The vast fund of ornithological and book lore possessed by this enthusiastic and kindly naturalist has been a constant inspiration. Mr. Dix Teachenor, an experienced taxonomist, has as-

sisted in determining subspecies, and has furnished for study a large series of sparrow skins collected in this region. Mr. B. F. Bush of Courtney, and Mr. Charles Tindall of Independence, have furnished valuable notes. Mr. Tindall has also loaned his



collection of skins. The notes of Mr. John A. Bryant have yielded several records as well as some early-day matter relative to species now extirpated or very rare. Mr. Charles E. Dankers of Corning, Holt County, who has made an extensive

collection of the larger birds of Northwestern Missouri, has given free access to his notes and specimens. Mr. A. F. Smithson of Warrensburg has contributed voluminous notes covering a period of several years. Mr. A. E. Shirling has assisted materially in bringing the list down to date. Among the sportsmen whose observations have been based on a knowledge of ornithology, Judge J. E. Guinotte of Kansas City, and Mr. R. P. Holland of Atchison, Kansas, have contributed matter of interest and value. The Kansas list of Mr. C. D. Bunker, Curator of the Kansas University Museum, and the admirable Missouri list of Mr. Otto Widmann have been freely consulted and a few records used.

Order PYGOPODES. Diving Birds.

Suborder **Colymbi.** Grebes.

Family COLYMBIDAE. Grebes.

AECHMOPHORUS OCCIDENTALIS (Lawrence). Western Grebe.

Accidental, possibly casual, visitant.

The Western Grebe has been taken once near Lawrence (Bunker), and there is a Missouri River record from adjacent territory on the north (southeastern Nebraska). While no specimen has been taken in this immediate vicinity, this grebe very possibly occurs on the Missouri River here as a casual visitant during migration.

COLYMBUS HOLBOELLI (Reinhardt). Holboell's Grebe.

Occasional visitant.

This rare bird has been taken but twice in this vicinity; once in 1854 and again on September 15, 1905. Two grebes observed on April 28, 1917, in the Missouri River overflow at the mouth of the Big Blue, were identified as this species. It is to be looked for during the migration seasons on any large pond or stream, but is more likely to occur on the Missouri River.

COLYMBUS NIGRICOLLIS CALIFORNICUS (Heermann). Eared Grebe.

Regular but rare migrant.

The Eared Grebe occurs from the middle of April to the first week in May, and again during the second week in November.

The small number of actual records for this bird in Jackson county may be accounted for by lack of enough suitable reedy lakes. Two specimens have been taken on the Missouri River near Courtney, and the bird has been observed at Lake City. It occurs regularly and in numbers, during migration, about the river lakes in Platte County.

PODILYMBUS PODICEPS (Linn.). Pied-billed Grebe.

Common migrant and rare summer resident.

The Pied-billed Grebe arrives from the last week in March to the middle of April, and leaves in late November.

This small grebe may be looked for on any small pond or stream. It has been frequently noted on all of the park lakes.

It is easy of approach and, on being disturbed, instead of taking wing will usually dive, hence the vernacular name Hell Diver.

The nest has never been found in Jackson County, but pairs of birds have remained all summer on Mill Creek, north of Independence (Bush), on Fish Lake, and on the lower Blue River. A nearly full grown young bird was seen at the mouth of Blue on June 13, 1916.

Suborder **Cepphi.** Loons and Auks.

Family GAVIIDAE. Loons.

GAVIA IMMER (Brunnich). Loon.

Rare migrant.

The few available records of this once common migrant indicate that it arrives from the north about the middle of October and returns during the first two weeks in April.

It is observed mainly on the Missouri River, though a specimen was taken at Lake City on October 10, 1902. It is still occasionally taken by duck hunters and a few individuals have been known to winter here during mild and open winters.

Order LONGIPENNES. Long-winged Swimmers.

Family STERCORARIIDAE. Skuas and Jaegers.

STERCORARIUS POMARINUS (Temminck). Pomarine Jaeger.

Accidental visitant.

A fine specimen of this unlooked-for ocean bird was secured by two duck hunters on the Missouri River near the Eaton Bar on November 28, 1915. The skin is now in the possession of Charles Tindall of Independence, and constitutes the only record for the state.

That there might be no question as to the identification, the specimen was forwarded to the Biological Survey at Washington and identified by Dr. H. C. Oberholser.

STERCORARIUS PARASITICUS (Linn). Parasitic Jaeger.

Rare winter visitant.

The Parasitic Jaeger has been taken several times by duck hunters on the Missouri River, though there are no specimens to substantiate the records. A flock of five were observed at close range near the mouth of the Big Blue River on April 23,

1916. There can be no question of the identification in this case, as the birds were close enough to show their distinctive characteristic, the *sharp* middle tail feathers a few inches longer than the others.

The older river men state that this bird was not uncommon in the days when the river was filled with refuse from the packing houses.

STERCORARIUS LONGICAUDUS Vieillot. Long-tailed Jaeger.

Accidental visitant.

A specimen of this bird was taken at Bean Lake in the spring of 1910 (Holland). On October 3, 1916, Mr. B. F. Bush watched two of these easily identified Jaegers worrying a bunch of Blue-winged Teal on the Missouri River near Courtney. Mr. Bush is a trained scientific observer and there can be no question as to this record, especially as the birds were within a few feet of him part of the time. These are the only known records for Missouri.

Family LARIDAE. Gulls and Terns.

Subfamily Larinae. Gulls.

RISSA TRIDACTYLA TRIDACTYLA (Linn.). Kittiwake.

Accidental.

The only record for this gull is that of Mr. J. A. Bryant, who took a specimen in the spring of 1897 (Widmann, p. 24). It has been impossible to verify this record, as the specimen does not seem to have been preserved.

LARUS ARGENTATUS Pontoppidan. Herring Gull.

Fairly common migrant.

The Herring Gull sometimes arrives in February, even when the river is filled with floating ice, as in 1916, but more often from the last week in March to the first week in April. This gull probably follows the Mississippi River south in the fall migration, as there are no records of its occurrence here at that season.

LARUS DELAWARENSIS Ord. Ring-billed Gull.

Not uncommon migrant.

Though there are but five authentic records of the occurrence

of this gull in this vicinity—Oct. 27, 1899, May 5, 1902 (specimen), Sept. 25, 1902, Apr. 18, 1915 and Apr. 12, 1917,—it probably occurs oftener than indicated by these figures. Unfortunately the observers most liable to see it (the river fishermen) are unable to distinguish it from the preceding species. Further observation may prove it to be as common, if not commoner, than the Herring Gull.

LARUS ATRICILLA Linnaeus. Laughing Gull.

Casual migrant.

The Laughing Gull has been repeatedly taken at Lawrence (six records, Bunker) and has been reported from points to the north and east (southeastern Nebraska and southern and central Iowa). It is probably a rare bird everywhere inland and has thus far escaped notice on the Missouri River in this immediate neighborhood.

LARUS FRANKLINI Richardson. Franklin's Gull.

Common migrant.

Long straggling flocks of these beautiful gulls begin to arrive from the south from the 10th to 20th of April and are but a few days in passing, as they are probably impatient to reach the breeding grounds. Late arrivals have been noted as late as the first week in May. They seem to be irregular in the autumnal flight; during some years but a few are seen, during others great numbers pass through. They straggle along in a leisurely manner, feeding as they go, from the middle of October to the last of November.

In the spring they are to be looked for on the Missouri River but in fall are likely to occur about any body of water.

LARUS PHILADELPHIA (Ord). Bonaparte's Gull.

Not very rare migrant.

Specimens of Bonaparte's Gull are occasionally shot by hunters on the Missouri River; more often in spring than autumn. Available records of specimens are as follows: Sugar Lake, May 5, 1897, Bryant; Missouri River, Jackson County, May 10, 1900, Tindall; Holt County, May 5, 1908, Dankers; Missouri River, Jackson County, December 8, 1917, specimen in collection of Miss Clements of Independence.

Subfamily STERNINAE. Terns.

STERNA CASPIA Pallas.

HYDROPROGNE CASPIA IMPERATOR (Coues). Proposed April, 1917.

Caspian Tern.

Occasional visitant.

Two specimens of this tern were taken by Chas. Tindall on the Missouri River near Courtney on October 14, 1914. Several more were secured, probably from the same flock, at the same place ten days later.

A specimen was taken at Lake City by Mr. J. A. Bryant in the spring of 1886. No other records are available.

STERNA FORSTERI Nuttall. Forster's Tern.

Not uncommon migrant.

Small flocks of Forster's Terns appear late in April and early May, and again in September and October. Recent data seem to point to the increase of this tern which, though formerly common, had later become very scarce.

These graceful birds may be looked for on the Swope Park lakes or any other large pond, as well as on the Missouri River.

STERNA HIRUNDO Linn. Common Tern.

Somewhat rare migrant.

The Common Tern is usually seen late in May or early June and again in October. It was formerly rather common. Some recent dates are May 10, 1916, when a flock of twelve were seen in Swope Park, and June 11, 1916, when fifteen were observed feeding in their characteristic manner about the mouth of Big Blue River.

STERNA ANTILLARUM (Lesson).

STERNULA ANTILLARUM ANTILLARUM Lessor. Proposed April. 1917. Least Tern.

Somewhat rare migrant and occasional summer resident.

Least Terns make their appearance in small numbers during the last few days in April in some years, but oftener in the first week of May. They leave for the South during the first fifteen days of September.

Prior to 1900 this dainty bird was commonly met with on the Missouri River and about neighboring ponds and marshes. It

remained to breed in small numbers in favorable localities in the Missouri bottoms. During the summer of 1915 a pair were seen throughout the entire breeding season at the mouth of Big Blue, where they no doubt had a nest.

This tern seems to be slightly on the increase; more individuals have been seen during the last four years than for thirteen years prior to that time.

HYDROCHELIDON NIGRA SURINAMENSIS (Gmelin). Black Tern.

Abundant migrant and not uncommon summer resident.

The first impatient males begin to arrive about April 26th, followed in increasing numbers all through May by the bulk of the flight and until mid-June by the stragglers. A flock of between fifty and a hundred birds have been seen migrating as late as June 11th.

These terns follow the Missouri River in flocks of several hundred individuals and resort to favorite feeding and resting places where they may be observed during every migration. The Big Eddy just below the mouth of Blue is one of these. Here the feeding flocks may be easily approached in a launch and the many plumage variations observed at close range.

This species has been seen about the Swope Park lakes, Penn Valley lake, Country Club pond and other small bodies of water in and around the city. They are observed during the entire summer at most of the duck-hunting resorts in this vicinity, and are very possibly breeding in favorable localities.

Several were seen hawking for insects over an athletic field in the Country Club region in company with Nighthawks on May 17, 1917.

Order STEGANOPODES. Totipalmate Swimmers.

Family ANHINGIDAE. Darters.

ANHINGA ANHINGA (Linn). Water-Turkey.

Formerly an occasional summer visitant.

A small flock of these curious Southern birds were observed by Bush on the Missouri River near old Wayne City (now Cement City), in 1882.

A specimen was taken by Bryant on the Missouri River at Parkville in 1898. This bird will possibly not be met with here again; it has been steadily driven south by the encroachments

of civilization until but a few pairs remain in the sunken regions of southeast Missouri.

Family PHALACROCORACIDAE. Cormorants.

PHALACROCORAX AURITUS AURITUS (Lesson). Double-crested Cormorant.

Rather rare migrant.

All available records but one of the occurrence of this bird here are in October and November, though it is known to pass regularly in the spring (two specimens, April 17, 1904, Dankers).

During occasional migrations it is seen in considerable numbers, as in 1904, when, on October 24th, a flock of between 100 and 150 were seen perched in the trees along the river bank across from the Big Eddy. Two specimens were taken from this flock. Again in the same year on November 17th a flock of twenty was observed on the river near Courtney.

The river fishermen know this bird as the Water-Turkey and state that rarely a season passes without their seeing it.

Family PELECANIDAE. Pelicans.

PELECANUS ERYTHRORHYNCHOS Gmelin. White Pelican.

Common migrant.

This locality is fortunate in being favored with spring and autumn visits from this, the largest member of the North American Avifauna.

Pelicans arrive from the south during the last week of March or very early in April and return from the 13th to 25th of September, straggling along in varying numbers until late in November.

They are still seen in considerable numbers, though not in such abundance as formerly. They seem to be holding their own of late years in spite of the odds against them.

Flocks of several hundreds of these majestic birds are often seen flying high over the Missouri Valley, when they present a sight not easily forgotten, as with alternate series of flapping and sailing they make their way rapidly along. Unless at too high an altitude they are not to be mistaken for any other water bird.

They have on at least one occasion been seen to make their

well-known concerted drive for fish into shallow water. This was observed at Goose Island in the Missouri River a short distance above the city.

Hunters only too often bring in specimens of Pelicans wantonly destroyed for "sport." Among these have been noted males, taken in the autumn, with the nuptial horn or mandible keel still retained. This temporary appendage is usually cast on the breeding ground before the southward flight begins.

Favorable localities, where they may rest and feed in seclusion, or where they are protected, have been known to harbor great numbers of these migrants for days and even weeks at a time. One lake in this district is visited twice a year by a flock of from 100 to 1,500 Pelicans. They sometimes remain on this pond for two weeks.

Order ANSERES. Lamellirostral Swimmers.

Family ANATIDAE. Ducks, Geese and Swans.

Subfamily Merginae. Mergansers.

MERGUS AMERICANUS Cassin. Merganser.

Not uncommon migrant; occasional winter resident.

Mergansers arrive late from the north, usually during the last half of November, and leave early, in some seasons as early as February, but more often in March and early April.

During the winter of 1910-1911 a flock of six were observed during the entire winter at the mouth of the Big Blue. Again in 1916 another larger flock wintered on a nearby pond, leaving early in March.

MERGUS SERRATOR Linn. Red-breasted Merganser.

Rare migrant.

This duck is occasionally seen in hunters' bags and is probably more often taken than the records indicate. Two beautiful specimens were examined in a gunner's string on March 18, 1916, on the Missouri River near Sugar Creek. There are a half dozen authentic records for the last few years.

LOPHODYTES CUCULLATUS (Linn.). Hooded Merganser.

Common migrant and formerly a not uncommon summer resident.

This striking duck is regularly taken by hunters on the river and at the many shooting resorts in this vicinity.

It remains during open winters in favorable localities and has been known to breed in the county. The dates of its occurrence here cover the entire year, though lately it is seen only during migration.

A flock of six nearly full-grown young were seen on Mill Creek, between Independence and Courtney, on June 17, 1892.

Subfamily Anatinae. River Ducks.

Anas platyrhynchos Linn. Mallard.

Abundant migrant, fairly common winter resident and occasional summer resident.

The Mallard is present in some numbers during every winter that the Missouri River remains open. The first birds from the north begin to arrive early in September, though the great flocks do not come through until the middle of October, when they are here in varying numbers until the last days of November and the first half of December. Unless the winter be exceptionally severe, the northward movement begins late in January and early February. By the last week in March the crest of the migratory wave has passed, though stragglers may be seen as late as the middle of May.

In former times the Mallard nested commonly along the Missouri River bottoms from its mouth, and Widmann states that a few still find safe breeding grounds in the large tracts of spartina grass in the marshes of north Missouri. Smithson found Mallards breeding near Warrensburg in 1903 and 1904. They have been known to breed also during recent years near Bigelow.

During the past two or three years there has been a very noticeable increase in the numbers of these and other ducks. The autumn flight of 1916 was decidedly larger than any seen for many years.

On January 29, 1917, there was a surprising southward flight of thousands of Mallards and Pintails. A severe blizzard followed the ducks, accompanied by a temperature of twelve degrees below zero. These birds had spent the winter up to this date in northern Missouri, although there had been periods during which all lakes and streams, except the Missouri River, had been frozen solid. The closing of the river during this blizzard probably accounts for this movement.

Malards are likely to drop into any small body of water during their migratory flights and are sure to be seen in Swope Park.

ANAS RUBRIPES RUBRIPES Brewster. Red-legged Black Duck.

Not uncommon but irregular migrant.

The well-known controversy relative to the validity of this form is an interesting incident in the history of systematic ornithology. It is included in this list in the firm belief that it is a perfectly good and valid subspecies and that it will one day be returned to the American Ornithologists' Check List.

Black Ducks with intensely red legs and feet are not uncommonly taken on the Missouri River and at the several duck-shooting resorts in this neighborhood. In some years only an occasional specimen is seen. A hunter's string was examined on October 27, 1917, that contained two specimens of this duck taken in Jackson County.

William Andrews, who lives on the Missouri River and who has spent a great many years hunting and fishing there, recognizes the two forms of the Black Duck, and states that he has killed hundreds of the Red-legged subspecies in his time. He states further that they are much less common than formerly and are somewhat irregular in their occurrence.

ANAS RUBRIPES TRISTIS Brewster. Black Duck.

Rare migrant.

This duck was formerly a common migrant and often present in winter. The older sportsmen recall the days when the "Black Mallard" was taken regularly.

It has been noted but a few times during the past 15 years and is now considered a rarity. Two specimens were taken on the Missouri River, Oct. 30, 1903, and Nov. 15, 1909, respectively.

CHAULELASMUS STREPERUS (Linn.). Gadwall.

Fairly common migrant.

The Gadwall is regularly met with on the Missouri River during March and April and in late October and November. A few single birds or small flocks are occasionally seen as early as the middle of February. A flock of over two hundred birds was seen on April 13, 1917, indicating that this species may be on the increase.

The Gadwall has been found nesting a few counties to the north.

MARECA AMERICANA (Gmelin). Baldpate.

Common migrant.

The Baldpate is often found in the company of the Gadwall. The migration dates of these two species are about the same, though the Baldpate has not been known to breed in the state. Fairly large flocks of these two ducks have been noted during the last two years; we believe that both are increasing in numbers.

The Baldpate is occasionally seen on the park lakes.

NETTION CAROLINENSE (Gmelin). Green-winged Teal.

Very common migrant; occasional winter resident.

The Green-winged Teal arrives from the north during October; a few remain during the mild open winters. By the last week of April all have left for their northern breeding grounds.

On account of their habit of flying in compact flocks and of circling back to the same spot again and again, great numbers of these beautiful little ducks are killed by hunters.

They have often been noted on the park lakes.

QUERQUEDULA DISCORS (Linn.). Blue-winged Teal.

Very common migrant and occasional summer resident.

This duck returns from the north early and is the last to depart in the spring. Blue-wings begin to arrive early in September, the bulk passing during the latter part of the month and in early October. A few are seen as early as February on their return but the bulk of the flight is not present until late in April and many are observed well into May.

Pairs of Blue-wings are observed all summer wherever there are favorable nesting sites and if not disturbed would breed in numbers in the county. A brood of five young with the parent birds were observed on Mill Creek several times in June, 1916 (Bush).

This is one of the species of water fowl that is fortunately showing an increase in numbers. It has been reported as breeding in great numbers in northern Missouri and in northern and central Kansas during the summers of 1915, 1916 and 1917.

It is not uncommonly seen on the Swope Park lakes.

QUERQUEDULA CYANOPTERA (Vieillot). Cinnamon Teal.

Occasional visitant.

This western species has been noted many times in this vicinity, usually in the company of its near relative the Blue-wing.

A pair taken by Bryant in 1904 were killed within the city limits. A flock of five were taken by Tindall at Lake City in 1895. A single bird was observed on a nearby lake on April 17, 1915. Another was seen on the same lake on April 15, 1916, where it remained for over a week. Still another record comes from the same place in April, 1917.

SPATULA CLYPEATA (Linn.). Shoveller.

Very common migrant; possibly a rare summer resident.

The arrival and departure dates of this duck are about the same as those of the Blue-winged Teal.

Pairs of these birds, observed every May lingering about ponds and swampy bottom land, are without doubt seeking nesting sites but are driven out by unfavorable conditions.

This beautifully marked and easily recognized duck is frequently seen on the park lakes.

DAFILA ACUTA (Linn.).

DAFILA ACUTA TZITZIHOA (Vieillot). Proposed April, 1917. Pintail.

Abundant migrant.

Next to the Mallard and Lesser Scaup this is our commonest duck. Its arrival and departure is coincident with that of the Mallard.

Tremendous flights of Pintails and Mallards occur every season over the Missouri Valley and present a wonderful and impressive sight to bird lovers. Even at night the flocks may be heard passing overhead and the different species may be distinguished by their notes. On favorable mornings when the migration is at its height, the observer may look in any direction and see dozens of the flocks showing every conceivable variation of flight formation. The most favorable time for observation, if there be no fog on the river, is early dawn and for an hour or so afterward.

The Pintail, or Sprig, is almost certain to be seen during every migration on the Swope Park lakes.

AIX SPONSA (Linn.). Wood Duck.

Rare migrant and summer resident.

This once plentiful duck was a common breeder in the Missouri and Blue Valleys but is now seen only occasionally. As late as 1909 a pair nested in the neighborhood of the 27th Street bridge on the Blue River. This pair had raised a brood in this place every summer for many years but were finally driven off. On June 13, 1916, two nearly grown young males were observed at the mouth of Big Blue.

Nearly every duck hunter in the county owns a mounted specimen of this beautiful bird taken in this region.

Subfamily Fuligulinae. Sea Ducks.

MARILA AMERICANA (Eyton). Redhead.

Not uncommon migrant.

The Redhead was once an abundant migrant here but has been scarcer of late years, though it is probably again on the increase.

It arrives during early March (sometimes much earlier) and April on the northward flight and in late October and November on its return. It is occasionally seen in December.

Duck hunters generally bewail the disappearance of this fast flying and valuable duck but take every opportunity to slaughter it on sight.

MARILA VALISINERIA (Wilson). Canvas-back.

Not uncommon migrant.

Like the Redhead, the Canvas-back has greatly decreased in numbers, until where formerly hundreds were observed, now only dozens are seen. It is still regularly taken by hunters, sometimes amid floating ice in the river as early as February. It is often seen with Redheads and its migratory periods are about the same.

MARILA MARILA (Linn.). Scaup Duck.

Not uncommon migrant.

The Scaup Duck arrives from the south in March and April, earlier during some short winters, and leaves from the first week in November to the middle of December. It generally consorts with the two following species. Of late years it has not been seen in such large flocks as formerly.

All three species of the Scaup Ducks are known to local hunters by the name of Blackjack, though this one is sometimes called Bluebill.

MARILA AFFINIS (Eyton). Lesser Scaup Duck.

Abundant migrant.

The common Blackjack ranks with the Mallard and Pintail in point of numbers and has not noticeably decreased during the past few years. A familiar sight on the Missouri River, when the bulk of the birds are passing through on the northward flight, is to see immense rafts of these ducks floating down stream with the current busily engaged in their mating antics. They have favorite stretches of water for these floats and when they have arrived at the end of one where they commonly "use," the entire flock leaves the water and flies, sometimes miles, to the starting point to begin the float all over again. During these times they are easy of approach though they are becoming more wary of the motor-boat than formerly.

This duck is not a very desirable table fowl but is slaughtered in great numbers by the city hunters.

It is often found in the company of other species but prefers to flock with its own kind. It is to be found here all through the migrating season in varying numbers, though never in midwinter, and is often seen in rather large flocks on the different park lakes. Flocks rest for days on the lake in Penn Valley taking no notice of the traffic but a few yards away. Flocks of considerable size are often seen on the lakes in Swope Park.

MARILA COLLARIS (Donovan). Ring-necked Duck.

Not uncommon migrant.

This species precedes the other Scaup in the spring and is often found with the early Redheads and Canvas-backs. It is not as common as formerly but is regularly taken by the hunters. It is the least numerous of the Scaup.

CLANGULA CLANGULA AMERICANA Bonaparte. Golden-eye.

Rather rare migrant.

This strikingly marked duck is now only occasionally seen in twos and threes on the Missouri River, where formerly it was met with in migration in occasional flocks of dozens. The last

visiting flock of any size was noted on March 11, 1914. Two specimens were examined in a hunter's string in the spring of 1916.

CLANGULA ISLANDICA (Gmelin). Barrow's Golden-eye.

Very rare winter visitant.

This northern bird seldom wanders so far south and there are but two authentic records of its capture in this immediate neighborhood.

CHARITONETTA ALBEOLA (Linn.). Buffle-head.

Irregular and not common migrant.

Never of very frequent occurrence, this small duck is as likely to be met with in February as in May, returning from the north in late October and November. During some years several small flocks are seen and in other years none. The rivermen call this duck the Butterball and say that it does not occur as frequently as formerly.

HERELDA HYEMALIS (Linn.). Old-squaw.

Very rare winter visitant.

Authentic records of the occurrence of this duck are few, though several of the river fishermen claim to know the bird and to have seen it several times. One specimen was taken by Bryant in 1893.

HISTRIONICUS HISTRIONICUS (Linn.). Harlequin Duck.

Very rare winter visitant.

There are but two records of the occurrence of this northern duck in this vicinity. One specimen was taken by Wm. Andrews on the Missouri River at the Eaton tower (date not available) and the other was killed at Lake City by Bryant in 1887.

ODEMIA AMERICANA Swainson. Scoter.

Irregular winter visitant.

River men claim to know this bird but the fact of its presence here was not authentically established until 1914. During the autumn flight of that year several dozen specimens were examined at different times. This was probably an exceptional invasion of this duck and the river hunters made the most of it.

OIDEMIA FUSCA (Linn.).

MELANITTA DEGLANDI (Bonaparte). Proposed April, 1917.

White-winged Scoter.

Accidental.

The only authority for including this bird is the mounted specimen in the Public Library, without data but said to have been taken near by.

OIDEMIA PERSPICILLATA (Linn.).

MELANITTA PERSPICILLATA (Linn.). Proposed April, 1917.

Surf Scoter.

Very rare winter visitant.

A female Surf Scoter taken by Charles Dankers, near Corning, and beautifully mounted by that naturalist, is the only record of the occurrence of this duck in this part of Missouri. There are five records from Lawrence, one given by Vernon Kellogg (K. C. Scientist, 1891), and four by Bunker.

ERISMATURA JAMAICENSIS (Gmelin). Ruddy Duck.

Not uncommon but irregular migrant.

Formerly a very common migrant, the Ruddy Duck has greatly diminished in numbers. It is irregular in its occurrence here, some years appearing in quite large numbers. A flock of between 50 and 100 was seen on March 15, 1916, floating down the Missouri River near the Hannibal Bridge.

Arriving early in March they hurry through and are back by the middle of October, and all have left by the last week in November.

Subfamily Anserinae. Geese.

CHEN HYPERBOREUS HYPERBOREUS (Pallas). Snow Goose.

Fairly common migrant.

The white geese begin coming late in February and are not usually seen after the first ten days in April. They pass through on their return flight from the middle of October to the middle of November.

Occasional records for mid-winter and early February have led some observers to assume that this goose remains during open winters. It would be so easy for birds with such powers of flight to go south even for a short period (as their near relatives, the Blue Geese are known to do) that this assumption seems not to be warranted by the present evidence.

Hunters, especially on the Missouri River, still bring in comparatively large numbers of these geese and they are becoming more scarce every year.

When the "Migratory Bird Act" is enforced, if not too late, it is hoped that all the geese will immediately begin to increase.

CHEN HYPERBOREUS NIVALIS (J. R. Forster). Greater Snow Goose.

Not very common migrant.

This form of Snow Goose is not of such regular or common occurrence as the preceding but is occasionally taken by hunters. Only a few large Snow Geese have been seen during recent years and it is considered much more rare than formerly. There are five authentic records of its occurrence here during the past several seasons.

It is difficult to distinguish in the field from the smaller form.

CHEN CAERULESCENS (Linn.). Blue Goose.

Common migrant.

The time of arrival and departure of this goose is about the same as the Snow Goose except that it does not arrive so early as February.

Though not so abundant as formerly, the presence here of some very large flocks during the past two years encourages the hope that the species may be on the increase. Flocks of from 50 to 250 are not uncommonly seen on the Missouri River.

ANSER ALBIFRONS GAMBELI Hartlaub. White-fronted Goose.

Fairly common migrant.

Small flocks of White-fronted Geese sometimes arrive as early as the last week in February but the main flight is about a month later. They return about the middle of October and the last are seen sometimes as late as early December. These occasional February and December records have led some observers to think that the bird remains in mild winters. This is not believed to be the case since extended field work during January in several open winters has failed to show them present.

Troops of a few dozen birds are commonly seen all through migration times on the Missouri River and on April 12, 1917, a flock of 250 was observed.

BRANTA CANADENSIS CANADENSIS (Linn.). Canada Goose.

Fairly abundant migrant and somewhat common winter resident. Formerly a summer resident.

Flocks of hundreds of these geese are still to be seen, especially in spring. The Canada Goose arrives in early February and March and leaves on the southward flight in November or December, depending on the severity of the season. Canada Geese have been frequently observed wintering here and it has been no uncommon sight to see these wintering flocks tumbling pell mell into the current of the Missouri River amid great fields and agitated masses of floating ice. Great numbers have been killed over decoys in January from blinds built of blocks of ice on sand bars and points.

The Wild Goose was a common breeder here in the early days in the bottom land jungles.

Several farmers in this vicinity have extensive flocks of domesticated Canada Geese which breed freely in confinement.

Fine specimens of this and the Snow Goose as well as several species of the commoner ducks are to be seen in the Swope Park Zoo.

Long lines of these geese pass over the city during every season and on stormy nights during migration may be heard honking low over the house tops.

BRANTA CANADENSIS HUTCHINSI (Richardson). Hutchins's Goose.

Fairly common migrant.

This small subspecific form of the Canada Goose is often seen in rather large flocks and is sometimes found flocking with its big relative.

Owing to increased activity in manufacturing and transportation, some of the wilder and more wary water fowl have of late years avoided certain stretches of the Missouri River where they formerly "used," but this does not mean that there has been a proportionate decrease in their numbers. They simply seek greater seclusion further up the river or lower down. This small goose, in particular, is seldom taken in the county but is fairly common elsewhere in the vicinity.

Its high pitched gabbling note was formerly an important element in the wild music so keenly enjoyed and appreciated by ornithologists.

Subfamily Cygninae. Swans.

OLOR COLUMBIANUS (Ord). Whistling Swan.

Very rare migrant.

The Whistling Swan is still occasionally seen on the Missouri River. In 1897 a specimen was taken in the east bottoms by Bryant. Two specimens were brought in by a river hunter on November 22, 1915.

The older sportsmen tell of many swans being taken in Jackson County in former years but they are unable to distinguish the two species.

OLOR BUCCINATOR (Richardson). Trumpeter Swan.

Formerly a migrant; probably now extinct in this vicinity.

The Trumpeter Swan was formerly a regular migrant in the Missouri Valley. The only known specimen is the one in the Library collection. This bird was taken by Bryant in April, 1900, on a pond at 75th and Holmes.

Order HERODIONES. Herons, Storks, Ibises, etc.

Suborder **Ibides.** Spoonbills and Ibises.

Family IBIDIDAE. Ibises.

PLEGADIS GUARAUNA (Linn.). White-faced Glossy Ibis.

Very rare migrant.

This species is said to breed regularly in Kansas, even north of this latitude, but has been taken in Missouri but twice. Chas. E. Dankers took a specimen October 8, 1907, in Holt County.

Suborder **Herodii.** Herons, Egrets, Bitterns, Etc.

Family ARDEIDAE. Herons, Bitterns, etc.

Subfamily Botaurinae. Bitterns.

BOTAURUS LENTIGINOSUS (Montagu). Bittern.

Common migrant and rare summer resident.

The Bittern arrives about April 10th and leaves by the end of October. It is found here in the breeding season in suitable localities but the nest has not been discovered. It is common in migration and is to be seen along the streams and about lakes, ponds and marshes. Even the small marshy spot in the

woods by the Swope Park rifle range attracts its occasional migrating Bittern. On October 26, 1916, one was flushed from the bare prairie south of the Country Club region. This is characteristic of this species as they migrate broadcast over the country and do not follow the streams as do others of their kind.

IXOBRYCHUS EXILIS (Gmelin). Least Bittern.

Fairly common migrant and not uncommon summer resident.

The Least Bittern arrives early in May and leaves in September. It has been known to breed in the marshy places about Lake City and would no doubt be found nesting commonly in the county if more suitable localities were to be found. Several pair were found breeding at Sugar Lake, Platte County, in 1916.

It is a shy bird and active only in the evening in the places where it nests.

Subfamily Ardeinae. Herons and Egrets.

ARDEA HERODIAS HERODIAS Linn. Great Blue Heron.

Common migrant and occasional summer resident.

Great numbers of these large herons migrate up and down the Missouri River and resort to sloughs, backwater and shallows around sand-bars to feed.

The earliest birds arrive around March 18th and all have left by the last week in November. They have been found nesting in the tall trees by the old Hiffner Lake near Atherton. A few are met with regularly every summer during the entire season in favorable feeding places in the Missouri Valley. These birds may nest close by or a dozen miles away as they fly long distances to feed. A pair observed during the summer of 1906 at the mouth of the Blue were believed to have a nest in the timber on the Clay County side but it could not be located.

HERODIAS EGRETTA (Gmelin). Egret.

Formerly a summer visitant and possible summer resident.

The Egret has not been seen in this vicinity for twenty years. It was observed on the Blue River above Dodson in 1895. It has been observed on the river lakes in Platte and Buchanan Counties in former years.

EGRETTA CANDIDISSIMA CANDIDISSIMA (Gmelin). Snowy Egret.

Accidental.

The only record for this part of the country is a beautiful specimen in the Dankers collection taken in Holt County on April 14, 1904.

FLORIDA CAERULEA (Linn.). Little Blue Heron.

Irregular summer visitant.

The few small flocks of these herons that have been seen here are wanderers from the south after the nesting season. Ten specimens testify to its occurrence in this vicinity. Eight of these were taken from one flock by Chas. Dankers on August 20, 1916.

BUTORIDES VIRESCENS VIRESCENS (Linn.). Green Heron.

Common summer resident.

The Green Heron arrives about the middle of April and is seldom seen after the first of October. Every small wooded creek has its nesting pairs. It nests in Swope Park and along the Blue River within the city. It is very common in the Missouri Valley and in the valley of the Little Blue. It begins laying shortly after the middle of May.

This heron is less shy than others of the family and falls an easy prey to many thoughtless gunners, and for this reason alone is noticeably decreasing in numbers.

NYCTICORAX NYCTICORAX NAEVIUS (Boddaert). Black-crowned Night Heron.

Rare migrant and possible summer resident.

The Black-crowned Night Heron arrives about the middle of April and leaves by the middle of October. It is much less common than formerly. It has been known to breed in the counties to the north of us but the nest has never been found in Jackson County. It should be looked for in suitable localities.

NYCTANASSA VIOLACEA (Linn.). Yellow-crowned Night Heron.

Very rare summer resident.

The only authentic record of the occurrence of this heron in this vicinity is a pair seen at a nearby hunting resort on April 17, 1915.

Order PALUDICOLAE. Cranes, Rails, etc.

Suborder **Grues.** Cranes, Courlans, etc.

Family GRUIDAE. Cranes.

GRUS AMERICANA (Linn.). Whooping Crane.

Occasional migrant.

Charles Dankers is more favorably situated for observing the large water birds than any other observer in this part of the state. He reports this large crane as very rare. He collected a specimen on April 14, 1904, saw one on March 27, 1913, and noted a small flock of five birds on his farm in the spring of 1906.

Jno. A. Bryant, who states that this bird was common formerly, took a specimen in the spring of 1893, in this county.

GRUS CANADENSIS. Little Brown Crane.

Rather rare migrant.

The Little Brown Crane migrates regularly through this region and has been taken in adjacent territory on all sides. There is little doubt that a few of the sight records of the Sandhill Crane in this region properly belong to the Little Brown, as the two are not readily distinguishable in the field.

GRUS MEXICANA (Muller). Sandhill Crane.

Regular and not very rare migrant.

In favorable localities in this vicinity a few of these magnificent birds are seen regularly during every spring migration and occasionally in the fall. The following are some of Charles Dankers' dates:

March 23, 1902, a flock of thirty were seen.
March 30, 1903, a flock of thirty were seen.
March 22, 1905, a flock of twenty were seen.
April 8, 1906, one specimen was taken from a flock of ten.
April 15, 1906, a single bird was taken.
October 18, 1909, three specimens were taken from a large flock.
April 2, 1910, one specimen was taken.
March 23, 1911, a flock of fifteen was seen.
March 30, 1912, seven birds were seen.

March 24, 1913, a flock of fifteen was seen.
March 21, 1916, a flock of ninety was seen.

In the spring of 1917 (date not received) several small flocks were seen.

These data show that the Sandhill Crane arrives during the last week in March on the northward flight and that it sometimes returns this way during October.

A small number of these noisy cranes were heard circling low over the mouth of the Blue one stormy night in March in 1909. Two were seen by Judge Guinotte on the Missouri River during the first week of October, 1917.

Suborder **Ralli**. Rails, Gallinules, Coots, etc.

Family Rallidae. Rails, Gallinules and Coots.

Subfamily Rallinae. Rails.

Rallus elegans Audubon. King Rail.

Not uncommon migrant and rather rare summer resident.

The King Rail arrives early in April and leaves in late October. It has been reported breeding about Lake City and nests regularly in the up-river counties.

This rail is well known to duck hunters who report it a regular and not uncommon migrant on the neighboring lakes and swamps.

Dankers has mounted a pair with three young which were taken on his place on July 26, 1903.

Rallus virginianus Linn. Virginia Rail.

Common migrant and rare summer resident.

Tindall found this rail nesting at Lake City in 1892, 1895 and 1903. It is commonly seen in migration in the marshy places it frequents and its dates of occurrence are about the same as the following species.

Porzana carolina (Linn.). Sora.

Common migrant and rare summer resident.

The Sora arrives about April 18th and leaves in late October. It was found nesting by Bush and Tindall at Lake City on August 22, 1896. A set of ten eggs was taken near Independence and is now in the collection of O. E. Sheley.

COTURNICOPS NOVEBORACENSIS (Gmelin). Yellow Rail.

Rare migrant.

On account of its very retiring habits this rail is seldom seen. Tindall took a specimen near Independence on April 14, 1901. Dankers took one specimen at Corning on May 5, 1904, and two on October 15, 1916, in an alfalfa field. This October record is the only fall record for the State of Missouri.

This bird is said to be a rare summer resident a few counties north of here, but this statement has never been verified.

[CRECISCUS JAMAICENSIS (Gmelin). Black Rail.]

Possible migrant and summer resident.

There are no available records of the occurrence here of this elusive little skulker but there can be little doubt that it visits this vicinity regularly. It is included in this list to call the attention of students to the possibility of establishing its presence here.

Subfamily Gallinulinae. Gallinules.

ICNORNIS MARTINICUS (Linn.). Purple Gallinule.

Accidental.

An immature Purple Gallinule was captured alive and in a starving condition in the east bottoms on December 30, 1915. The skin is now in the collection of Miss Jennie Clements of Inedependence and is the only known record for this part of the country. There are but two other records for the State of Missouri.

GALLINULA GALEATA (Lichtenstein).

GALLINULA CHLOROPUS CACHINNANS Bangs. Proposed October, 1916. Florida Gallinule.

Not uncommon migrant and very rare summer resident.

For some unknown reason this bird arrives here about two weeks or more earlier than at St. Louis. Widmann reports that it arrives there after the first of May, but it has been seen here during several years from the 13th to 25th of April.

It was found nesting at Lake City by Tindall in 1904 and has been seen during the breeding season in Platte County in 1916 and 1917.

This bird was once very common and has only of recent years become rare.

Subfamily Fulicinae. Coots.

Fulica americana Gmelin. Coot.

Abundant migrant and not uncommon summer resident.

The bulk of the flight comes rather late, just ahead of the Blue-winged Teal and Shovellers, though a noticeable number are here often as early as the last week in February (twenty on Feb. 25, 1917). They begin leaving in September and very few are seen after early November.

Coots breed in the county wherever they can find suitable nesting sites. A pair nested on the Blue within the city limits during the summer of 1913, but succeeded in raising only one young. Immediately on the opening day of the shooting season all three birds were promptly slaughtered by the first hunter that passed on his way to the Missouri River.

Tremendous flocks of Mudhens migrate up the Missouri Valley and one flock seen on April 13, 1917, was estimated to contain ten thousand birds.

During the flight they are commonly seen on all the park lakes and city ponds.

Order LIMICOLAE. Shore Birds.

Family Phalaropodidae. Phalaropes.

Phalaropus fulicarius (Linn.). Red Phalarope.

Very rare migrant.

The Red Phalarope is said by several of the river-fishermen to occur now and then during migration, but authentic records are scarce. A specimen was taken on the Kaw River near Lawrence on November 5, 1905; another specimen, the head and feet of which were examined, was taken by Wm. Andrews on the Missouri River in Jackson County on October 20, 1917. A few unauthenticated records are known.

Lobipes lobatus (Linn.). Northern Phalarope.

Casual, probably accidental.

The only known record of the occurrence of the Northern Phalarope in this region is the specimen referred to by Widmann (p. 63), which was taken in Platte County, opposite Leavenworth. This species can be of only casual occurrence in this part of the country.

STEGANOPUS TRICOLOR Vieillot. Wilson's Phalarope.

Fairly common migrant.

The Wilson's Phalarope arrives from about April 20th to 25th (April 11, 1916) and again in August and September. Has been seen in spring as late as the middle of May.

Whenever the mud flats at the mouth of the Blue River are not submerged by backwater from the Missouri, large numbers of these beautiful birds resort there to feed and rest during their long migratory flights. They have been taken both in the showy spring plumage and the more sombre winter dress.

Family RECURVIROSTRIDAE. Avocets and Stilts.

RECURVIROSTRA AMERICANA Gmelin. Avocet.

Very rare migrant.

Rivermen have given us descriptions of birds taken which seem to apply to this species, but we have been able to find only the following actual records: Wm. Andrews took a specimen on the Missouri River near the Eaton tower in the spring of 1912. Bush reports one taken near Courtney in the spring of 1914. Bryant took a pair at Bean Lake in October, 1894.

Family SCOLOPACIDAE. Snipes, Sandpipers, etc.

PHILOHELA MINOR (Gmelin). Woodcock.

Very rare migrant and former summer resident.

Bush states that the Woodcock formerly nested in this county, but was never numerous either as a migrant or breeder.

Two were taken on the old Kenoche farm near the mouth of Big Blue by Bryant in the spring of 1894. Another specimen was taken near the same place by Dick Spiker on March 18, 1914. One was seen feeding in Shilo on May 30, 1915, by Walter Cunningham.

Very few of the great numbers that winter in the southeastern part of the state seem to come this way on their spring migration; it is probable that the bird is nearly extinct in this part of the country.

GALLINAGO DELICATA (Ord). Wilson's Snipe.

Fairly common migrant.

This once abundant game bird was formerly a common sight on every wet grassy spot. It is still present from about the

10th of March to the end of April (often later) and again from the first of September to the middle of November.

It still occurs in enough numbers to attract sportsmen and Jacksnipe shooting has not yet become obsolete for lack of victims.

A flock of a dozen or two spent a week on the wet meadow adjoining the Swope Park rifle range in early May of 1917. This is a favorable feeding place where they may be looked for every spring when conditions are right.

Fast-flying flocks of these birds are a rather common sight on the Missouri River during migration.

[MACRORHAMPHUS GRISEUS GRISEUS (Gmelin). Dowitcher.]

Probable migrant.

While there are no specimens at hand to establish the occurrence of this bird here, there is no doubt that it passes up the Missouri Valley in its migration. A flock of shore birds seen at the mouth of the Big Blue late in the spring of 1916 was rather unsatisfactorily identified as belonging to this species or to the subspecies *scolopaceus*. It is listed here in order that students may be on the lookout for it.

MACRORHAMPHUS GRISEUS SCOLOPACEUS (Say). Long-billed Dowitcher.

Rare migrant.

A pair of these birds were collected by Dankers in Holt County on October 16, 1916. Lack of data prevents the working out of the migration periods. It is understood to have been common formerly, but has become a rare bird.

MICROPALAMA HIMANTOPUS (Bonaparte). Stilt Sandpiper.

Rather rare migrant.

A small flock of six birds was observed at the mouth of Big Blue on April 16, 1914. A specimen was taken near the city by Tindall on April 17, 1902, and another on April 30, 1902. Further migration data are lacking.

TRINGA CANUTUS Linn.

CANUTUS CANUTUS RUFUS (Wilson). Proposed April, 1917. Knot.

Occasional migrant.

A beautiful specimen of this bird in full spring plumage was

taken on the lower Blue River on May 6, 1914, and another seen in the same place on May 8, 1914. A specimen has been reported from Platte County and another from a point about forty miles to the west. No other datum is at hand.

ARQUATELLA MARITIMA MARITIMA (Brunnich). Purple Sandpiper.

Accidental.

The Purple Sandpiper is listed on the strength of the specimen taken near here by Dr. Hoy in 1854 (19th Annual Report Smithsonian for 1864).

PISOBIA MACULATA (Vieillot). Pectoral Sandpiper.

Very common migrant.

The Pectoral Sandpiper arrives from the 12th to 18th of April, in some years much earlier (March 15, 1905; March 30, 1911; March 24, 1916), and is present until the last of May. It is seen sometimes as early as the middle of August, on the return flight from the north, and the last birds have not passed until early November. It is often observed in very large flocks along the Missouri bottoms about suitable shallow feeding places.

During the passing of the bulk of the flight, usually the last week in April, small flocks have been seen about the lagoon in Swope Park.

PISOBIA FUSCICOLLIS (Vieillot). White-rumped Sandpiper.

Not uncommon migrant.

This bird has been frequently observed on the river and a few times on ponds. All the available dates of its appearance are in the first week in May. The migration periods have not been worked out.

PISOBIA BAIRDI (Coues). Baird's Sandpiper.

Not uncommon migrant.

The Baird's Sandpiper is present from the middle of April to the first of June and from the last of August to nearly the middle of October (October 13, 1893). It is usually found with other small sandpipers. A recent record is one specimen taken on the Missouri River, near Courtney, by A. F. Frazier. on April 17, 1914.

PISOBIA MINUTILLA (Vieillot). Least Sandpiper.

Very common migrant.

The Least Sandpiper arrives as early as the 2nd of April and is present until the last week in May. The earliest southbound flock noted was on July 12, 1914, about three weeks earlier than the average time of arrival. The last have usually left by the last week in October.

This sandpiper is still seen in apparently as large numbers as formerly. It may be looked for about any small pond or stream, though most abundant on the sloughs and mud flats in the Missouri River flood plain.

PELIDNA ALPINA SAKHALINA (Vieillot). Red-backed Sandpiper.

Rare migrant.

A flock of fifteen Red-backed Sandpipers were closely watched on the mud flat at the mouth of the Blue on May 16, 1914. There are records of its occurrence here during four other years when specimens were taken.

The characteristic field mark of this bird in spring is the black belly. The student must not be led astray when he has under observation small shore birds of other species that have waded out in soft mud and stained the under parts.

EREUNETES PUSILLUS (Linn.). Semipalmated Sandpiper.

Very common migrant.

The migration dates for the Semipalmated Sandpiper are about the same as for the Least Sandpiper. These two species are among the commonest shore birds and occur in about equal abundance. They are found along the river sometimes in immense flocks and are often accompanied by other small sandpipers and Semipalmated Plovers.

While feeding these flocks may be easily approached and studied at close range, as they are not so wild as the larger shore birds which are more often disturbed by gunners.

EREUNETES MAURI Cabanis. Western Sandpiper.

Occasional migrant.

Several specimens of this sandpiper have been taken in this part of the country, both to the east and west, but not in this immediate neighborhood. It has been identified two or three

times in spring flocks of other shore birds, but no specimens have been taken.

CALIDRIS LEUCOPHAEA (Pallas). Sanderling.

Occasional migrant.

A small flock of six Sanderlings was seen on March 21, 1902, and a single specimen was taken on April 17, 1902. There are no further local data for this species.

LIMOSA FEDOA (Linn.). Marbled Godwit.

Rare migrant.

This large wader, though formerly common, has become quite rare. A small flock was seen on the river April 18, 1911. Two specimens in the Dankers collection were taken May 8, 1908.

LIMOSA HAEMASTICA (Linn.). Hudsonian Godwit.

Rather rare migrant.

The Hudsonian Godwit is occasionally seen in small flocks on the Missouri River. A group of nine finely mounted birds in the Dankers collection were taken on that farm May 15, 1910. A few birds were seen April 20, 1911, and a flock of twelve were observed on April 28, 1916.

TOTANUS MELANOLEUCUS (Gmelin). Greater Yellow-legs.

Fairly common migrant.

The Greater Yellow-legs arrive from the south from the 18th to 22nd of March, becoming fairly common between April 10th and 20th and are rarely seen after the first of May (two late dates are May 6, 1914, and May 9, 1914). They are found here irregularly in the fall from the first of September to the middle of November.

TOTANUS FLAVIPES (Gmelin). Yellow-legs.

Fairly abundant migrant.

The pleasing double and triple whistle of the Yellow-legs is to be heard on all sides in favorable places when the spring flight is at its height, usually from the 12th to 25th of April. The migration dates are about the same as for the preceding species, except that it remains a little longer on the northward flight and arrives earlier on the return, usually about the middle of August.

An exceptionally heavy flight during the latter part of April,

1917, is a hopeful sign that the bird is at least not materially decreasing in numbers.

It is often seen along the Blue, especially along the lower reaches, and about the Swope Park lagoon.

HELODROMAS SOLITARIUS SOLITARIUS (Wilson). Solitary Sandpiper.

Very commmon migrant.

The Solitary Sandpiper is present in spring from the middle of April to the middle of May and in autumn from the middle of August to early in October, an exceptionally late date being October 31, 1901.

It is to be found everywhere along waterways, lakes, ponds, and even woodland pools. It was found late in April, 1917, with the Bittern and Grinell's Water Thrush in the little swampy place in the timber just off the rifle range in Swope Park. During migration it is common all along the Blue and even on Brush Creek.

CATOPTROPHORUS SEMIPALMATUS SEMIPALMATUS (Gmelin). Willet.

Not rare migrant.

The Willet has been seen infrequently of late years, but its plaintive whistle is regularly heard at night during migration, especially in blustery weather. This may, of course, be the western form, but both occur here. A specimen taken by Bryant on April 9, 1903, is said to be referable to the eastern form, but has not been examined. Two specimens have been taken thirty miles west of this county.

CATOPTROPHORUS SEMIPALMATUS INORNATUS (Brewster). Western Willet.

Rare migrant.

Three birds of this subspecies were taken from a flock on a slough in the Missouri bottoms on May 6, 1914. This is all the local data on this bird available at this time.

BARTRAMIA LONGICAUDA (Bechstein). Upland Plover.

Not uncommon migrant and rare summer resident.

This fine game bird was formerly abundant on the prairie regions of Jackson County and was brought in in great numbers by

sportsmen. The prairie around Waldo and what is now the Country Club district were favorite hunting grounds and an occasional migrant is still seen in that vicinity.

They formerly bred commonly in the county and a nesting pair were seen by Bush as late as 1902 near Swope Park. Two sets of eggs were taken near Independence by Tindall on June 11, 1891, and June 17, 1891, respectively. A few specimens have been taken lately by Dankers.

The Upland Plover is often heard migrating at night in the last week of April and in August and September.

TRYNGITES SUBRUFICOLLIS (Vieillot). Buff-breasted Sandpiper.
Rather rare and irregular migrant.

This bird, sometimes called the Grass Snipe, appears during the last half of April and first half of May and again in September. During some years it is not seen. It generally occurs in small flocks and but few specimens have ever been taken here. Chas. Tindall took nine birds from a rather large flock on a sandbar in the Missouri River near the Eaton bend on September 15, 1901.

This sandpiper may be looked for on the uplands as well as near water.

ACTITIS MACULARIUS (Linn.). Spotted Sandpiper.
Very common migrant and not uncommon summer resident.

The Spotted Sandpiper arrives about April 20th (April 9, 1915, earliest) and but few are seen after the middle of October. The bulk of the flight passes north in early May and south in September. These birds are present in some numbers all through the summer.

In migration Spotted Sandpipers may be looked for wherever there is water, but in summer are found only on or near the Mis souri River.

NUMENIUS AMERICANUS Bechstein. Long-billed Curlew.
Occasional migrant.

Hunters seem to know this bird very well, but are unable to give any information regarding it except that it was once common and is now rarely seen.

Only six authentic records are known of its occurrence here. One is given by Bush, who saw a flock of seven in the spring of

1906. A single bird was observed May 25, 1905. Two specimens have been taken by Bryant at Cooley Lake and Lake City respectively. Four birds were seen by Judge Guinotte on a sandbar near Sibley on November 2, 1917.

NUMENIUS BOREALIS (J. B. Forster). Eskimo Curlew.

Formerly common spring migrant, now probably extinct.

This curlew, like the Golden Plover, migrates south over the Atlantic Ocean from Nova Scotia in the fall, only a few choosing the inland route at that season, but all return in the spring up the Mississippi and Missouri valleys. No specimen of this once common game bird has been seen in this vicinity for many years and it is now considered nearly, if not quite, extinct.

Family CHARADRIIDAE. Plovers.

SQUATAROLA SQUATAROLA (Linn.).

SQUATAROLA SQUATAROLA CYNOSURAE Thayer & Bangs. Proposed October, 1916. Black-bellied Plover.

Very rare and irregular migrant.

This bird was a not uncommon migrant prior to 1890; it has now become so rare that many years pass without one being seen. None had been seen or reported for five years prior to 1916, when Tindall killed one out of a small flock on the Missouri River near Courtney on November 13th.

CHARADRIUS DOMINICUS DOMINICUS (Muller). Golden Plover.

Not rare migrant in spring; very rare in autumn.

Like the Upland Plover, the Golden Plover was formerly taken in great numbers on the prairie regions of western Jackson County. It is now greatly reduced in numbers, though small flocks are still seen during the latter part of April and rarely in October and November, as the bulk of the flight in autumn takes the Atlantic route.

It is to be looked for on the uplands as well as about marshes and swampy places.

OXYECHUS VOCIFERUS (Linn.). Killdeer.

Common migrant and not uncommon summer resident.

The early arrivals from the south appear from the middle to the last of February and a month later the bulk of the mi-

grants are here. The heaviest flight is here again during September and early November.

The Killdeer may be looked for everywhere about water, in upland fields and meadows, and on the prairies. It has been frequently seen in Swope Park.

AEGIALITIS SEMIPALMATA (Bonaparte). Semipalmated Plover.
Fairly common migrant.

This little plover is usually found in the company of other small shore birds and is not often found far from the Missouri River. The earliest date of arrival is April 19th (1899 and 1914). It is present until the middle of May and again from about the 10th of August until late in September.

AEGIALITIS MELODA (Ord). Piping Plover.
Very rare migrant.

The Piping Plover occurs occasionally on the Missouri River. Only one specimen has been taken in the vicinity.

PODASOCYS MONTANUS (J. K. Townsend). Mountain Plover.
Accidental.

Bush asserts that several pairs of these western birds nested in the meadows near Courtney in 1887. He states that they have been found in small numbers during a few other years, but the bird can be considered as only accidental here.

Family APHRIZIDAE. Surf-birds and Turnstones.

Subfamily Arenariinae. Turnstones.

ARENARIA INTERPRES MORINELLA (Linn.). Ruddy Turnstone.
Occasional migrant.

A flock of seven of these birds was seen on the Missouri River, in Jackson County, on April 30, 1903. There are only two records of specimens taken in this vicinity, the latest being on October 20, 1917, by William Andrews, on the Missouri River, near Courtney.

Suborder **Phasiani.** Pheasants, Grouse, Partridges, Quails, etc.

Family ODONTOPHORIDAE. Bob-whites, Quails, etc.

COLINUS VIRGINIANUS VIRGINIANUS (Linn.). Bob-white.
Common resident.

The Bob-white nests regularly within the city limits. In 1915

five nests were found inside the southern and western boundaries. Winter coveys are likely to be found anywhere in the county, in the Missouri bottoms, on the prairie regions or wherever there is suitable cover.

The local migrations of these birds from exposed to more sheltered places, spoken of by Widmann, has once been observed by Bush. He saw a large covey alight in an exhausted condition on the river bank near old Wayne City after having crossed a wide expanse of river. Several of the birds were unable to make the flight and fell into the current.

An occasional albino is seen and there are several specimens extant.

Family TETRAONIDAE. Grouse, Spruce Partridges, Ptarmigans, etc.

BONASA UMBELLUS UMBELLUS (Linn.). Ruffed Grouse.

Former resident; now extinct.

According to Bush, the Ruffed Grouse made its last stand in the wooded hills of the Little Blue in the southeastern part of the county. They were long ago driven out by the settling of the country and only the older sportsmen remember them.

The specimen preserved by Bryant was taken by him near Independence in 1874.

TYMPANUCHUS AMERICANUS AMERICANUS (Reichenbach). Prairie Chicken.

Former resident; probably now extinct in this county.

A Prairie Chicken seen in the southeastern part of the county in 1915 was probably a straggler from the north, as the bird has not been regularly noted here since late in the nineties.

It was formerly abundant about the city and as late as 1884 resorted regularly in the evenings to a feeding place on what is now known as Hospital Hill.

Tindall found a nest containing twelve eggs near Independence on May 7, 1891. Three specimens in the Dankers collection were taken prior to 1904. This bird is gone from Jackson County never to return.

Family MELEAGRIDAE. Turkeys.

MELEAGRIS GALLOPAVO SILVESTRIS Vieillot. Wild Turkey.

Formerly an abundant resident. Now extinct in this vicinity.

Many records exist testifying to the local abundance of the Wild Turkey in early days. The latest dates are given by Bryant, who says: "Killed in Swope Park region in 1863. Many killed on Little Blue several years later."

It is reported from several districts in south Missouri, especially in the southeastern part, that the Wild Turkeys find the cover of the second-growth timber very much to their liking and that they have materially increased during recent years.

Order COLUMBAE. Pigeons and Doves.

Family COLUMBIDAE. Pigeons and Doves.

ECTOPISTES MIGRATORIUS (Linn.). Passenger Pigeon.

Formerly an irregular visitant in immense flocks. Now extinct.

Tremendous hordes of Wild Pigeons formerly visited this region. Bush says that in the autumn of 1879 the country southwest of Independence was visited by millions of them. Bryant says: "Passenger Pigeons here in 1873 and 1874. Killed fifteen at one shot in September, 1873."

ZENAIDURA MACROURA CAROLINENSIS (Linn.). Mourning Dove.

Very common summer resident; somewhat rare winter resident.

The Mourning Dove is found everywhere in the county, arriving generally from the first week to the last week in March and leaving in October and November. Single birds and flocks of from three to six have been found wintering here during the last five winters.

They lay their two eggs early in May and raise two and sometimes three broods. A nest is occasionally found containing three or four eggs, when two females use the same nest. The nest is a makeshift affair and may be found on top of horizontal limbs, low down or high up, in forks, on stumps, in vines, and even on the bare ground.

The Dove builds its nest in the city in favorable localities, such as the Country Club and Rockhill regions, Cliff Drive, Swope Park, and all the cemeteries.

[ZENAIDURA MACROURA MARGINELLA (Woodhouse). Western Mourning Dove.]

Recent subspecies. Probable migrant and summer resident.

This recently separated form is said to range eastward into the Mississippi Valley. When more specimens have been taken for comparison, it will without doubt be found to occur regularly in migration as well as in summer.

Order RAPTORES. Birds of Prey.

Suborder **Sarcorhamphi.** American Vultures.

Family CATHARTIDAE. American Vultures.

CATHARTES AURA SEPTENTRIONALIS Wied. Turkey Vulture.

Common migrant and summer resident.

A few Turkey Vultures arrive from the south in the latter part of February, but more often in the first half of March. They leave during November and December, though a few may remain into the first week in January.

The Buzzard nests in secluded places throughout the county, chiefly in the cliffs along the water courses. Fifteen or twenty pairs (twenty-seven birds have been seen circling at one time) nest regularly in the rocky ledges in and about Swope Park and have a common roost near the point where the Hickman's Mills Road branches.

They begin laying from the middle of April to the first of May and build no nest. The two beautifully marked eggs are to be found on the bare ground among rocks, in stumps, hollow trees and logs.

Suborder **Falcones.** Vultures, Falcons, Hawks, Buzzards. Eagles, Kites, Harriers, etc.

Family BUTEONIDAE. Hawks, Eagles, Kites, etc.

ELANOIDES FORFICATUS (Linn.). Swallow-tailed Kite.

Occasional summer visitant; rare summer resident.

Recent dates for the Swallow-tailed Kite, given by Bush, are as follows: In the summer of 1912 two pairs nested in the bottoms near Courtney; on March 22, 1916, one was seen at Court-

ney; on July 8, 1916, two were seen at Courtney, remaining in the neighborhood for about two weeks.

Tindall took a specimen near Independence on July 16, 1904, and another on September 1, 1906. The specimen in the Library collection was loaned by O. E. Sheley, who killed the bird near Independence.

Bryant states that a pair nested just southwest of Waldo several years ago, but does not furnish the date.

Several other observers have seen this graceful bird in the timbered regions of the Missouri Valley during recent years.

ICTINIA MISSISSIPPIENSIS (Wilson). Mississippi Kite.

Rare migrant.

The Mississippi Kite has been reported from several points in Missouri adjacent to this district on the north and east. Several specimens have been taken near Lawrence (Bunker and Wetmore, September 13-16, 1907), and there are later records, not available, of its occurrence in that neighborhood. This kite probably occurs in Jackson County during migration and should be looked for about open wooded places where cicadas are plentiful, or in fields and meadows where grasshoppers are found.

CIRCUS HUDSONICUS (Linn.). Marsh Hawk.

Common migrant and rare winter resident. Formerly a rare summer resident.

The Marsh Hawk is seen ranging over the prairie regions as well as in the Missouri bottoms and swampy and marshy places from about March 12th to about April 25th and on the return from September 15th to between December 28th and January 7th. At least two birds remained near the Country Club district during the entire winter of 1916-1917. An earlier winter record is February 13, 1898.

Though a common summer resident not far to the north and formerly a rare breeder in this vicinity, it has not been found nesting here for several years.

ACCIPITER VELOX (Wilson). Sharp-shinned Hawk.

Uncommon migrant and summer resident.

A few Sharp-shinned Hawks are seen during each migration about wooded places and along streams, but they are never com-

mon. There are only a few summer records and none for winter.

ACCIPITER COOPERI (Bonaparte). Cooper's Hawk.

Common migrant and summer resident; occasional winter resident.

This harmful species arrives during the first few days in March and is present until late October. There is but one winter record (January 20, 1917) and no specimens have been taken during midwinter, though Bush says that it is present throughout the entire year.

The nest is found in timbered places, usually in a fork about thirty feet high, and a full clutch is four or five eggs. Four sets in the Tindall oological collection, two of four and two of five eggs, were taken near Independence between the 1st and 29th of May.

This hawk may be looked for about the Swope Park region and in the country west of Dodson, as well as in the timbered bottoms of the Missouri River country.

ASTUR ATRICAPILLUS ATRICAPILLUS (Wilson). Goshawk.

Very rare and irregular winter visitant.

At infrequent intervals this northern hawk is known to invade this part of the country during the late fall and winter. The winter of 1916-1917 witnessed such an invasion. Over fifty specimens were sent in to the University Museum at Lawrence during the winter, most of which had been taken in the neighborhood. One was killed near Dodson and another seen on December 5, 1916.

Three specimens in the Dankers collection were taken February 17, 1902, November 2, 1906, and December 1, 1906, respectively.

Goshawks may be looked for here only during the most severe winters.

BUTEO BOREALIS BOREALIS (Gmelin). Red-tailed Hawk.

Common resident.

Red-tailed Hawks are present in numbers throughout the winter; they become more numerous late in February and the bulk of the migrants are here around the 12th of March. By the last week in March the local birds are nesting. Sixteen sets of eggs collected by Tindall of from one to three eggs each

were taken between March 19th and April 12th. The nests are usually found in very tall trees in the Missouri bottom lands and less frequently in timbered places elsewhere in the county.

The bulk of the returning migrants pass through during the latter part of October and early November. The wintering birds are to be found hunting in the prairie regions as well as in the timbered bottoms.

This hawk is a great destroyer of vermin and instead of being shot on sight by farmers and sportsmen should be protected and encouraged to remain.

BUTEO BOREALIS KRIDERI Hoopes. Krider's Hawk.

Occasional visitant during migration.

Krider's Hawk has been observed a few times on the prairie regions south of the Country Club district near open timbered places. On October 15, 1916, one was studied at close range and identification was made certain.

A specimen taken by Dankers was killed October 16, 1898.

This light phase of the Red-tail is nowhere common but this vicinity is a favorable locality to look for it during migration and possibly in winter. More data relative to its local occurrence is desired.

BUTEO BOREALIS CALURUS Cassin. Western Red-tail.

Rare winter visitant.

A Western Red-tail was closely observed in the Brush Creek timber just inside the state line on November 5, 1916. Many Red-tails suspected of belonging to this dark race are seen every winter but only one specimen has been taken to prove its occurrence in the vicinity—November 7, 1913.

BUTEO BOREALIS HARLANI (Audubon). Harlan's Hawk.

Casual visitant.

A specimen of this southern hawk, taken on a farm about twelve miles from Kansas City, was mounted by Kreite, a local taxidermist, in 1916. The specimen was not personally examined but is vouched for by Mr. J. F. Frazier, whose identification cannot be questioned.

BUTEO LINEATUS LINEATUS (Gmelin). Red-shouldered Hawk.

Uncommon migrant and summer resident.

Widmann says that as a summer resident in Missouri this

hawk far outnumbers its cousin the Red-tail, but this is not true of this part of the state where the latter greatly predominates.

The Red-shouldered Hawk is present during the entire year but is never common. The dates of occurrence of migrants are about the same as those of the Red-tail.

A favorite resort for these birds is the wooded bluff regions along the Missouri Valley.

BUTEO SWAINSONI Bonaparte. Swainson's Hawk.

Occasional migrant.

Swainson's Hawk but rarely straggles into the county and then only during migration.

Dankers has taken two specimens during recent years. A pair have been found nesting about thirty miles southwest of this county.

We have very little additional data as to the local occurrence of this hawk.

BUTEO PLATYPTERUS (Vieillot). Broad-winged Hawk.

Rather rare summer resident.

The earliest record of the arrival of the Broad-winged Hawk in spring is April 8, 1914. All other recorded dates are near the end of the month. It usually leaves late in October.

It was found nesting near Independence in June, 1900 (Tindall). A nest was located in the wooded bend of the Blue River south of the rifle range in Swope Park in May, 1917. A pair were disturbed while perched on an unfinished nest in a tall tree in the timber near the mouth of the Blue in the spring of 1914. This was an unusual place for these birds as they prefer the upland woods to the bottom land.

ARCHIBUTEO LAGOPUS SANCTI-JOHANNIS (Gmelin). Rough-legged Hawk.

Fairly common winter visitant.

The Rough-leg arrives from the north as early as October 28 (1916), though more often a week or two later. It is not often seen after March 12th (an exceptionally late date is April 4, 1917).

It may be looked for during winter, in any place in the

county where there is suitable cover for small rodents, as it is a persistent hunter of such game. It is commonly seen in the Missouri bottom lands as well as on the prairie country.

Many intergrades between the different color phases have been noted.

[ARCHIBUTEO FERRUGINEUS (Lichtenstein). Ferruginous Rough-leg.]

Probable winter visitant.

This hawk is thought to occur irregularly in winter on the prairie country along the western border of the county but not sufficient data have been obtained to establish the fact definitely. The few field identifications have been unsatisfactory and no specimen has been taken.

AQUILA CHRYSAETOS (Linn.). Golden Eagle.

Very rare winter visitant.

Seven specimens of the Golden Eagle are known to have been taken during recent years in this vicinity. It is probable that many more have been taken. It was formerly more common and only during the past few years has become a rarity.

HALIAEETUS LEUCOCEPHALUS LEUCOCEPHALUS (Linn.). Bald Eagle.

Rare winter visitant. Formerly a very common winter resident and rare summer resident.

The older river shooters well remember the days when the Bald Eagles were here in fall and winter in great numbers along the river. In those days the sand-bars and low banks were fringed with red offal from the packing houses and Bald Eagles came in droves to the feast. Not until the packers began utilizing all their waste did these big birds disappear as regular winter visitants in numbers.

They formerly nested in the tall trees in the deep wooded bottoms along the Missouri River. One early account even speaks of a nest on a farm on the old Lexington Road (Swope farm, Bryant).

They are still occasionally seen soaring above but must now be classed among the rare species.

Family FALCONIDAE. Falcons, Caracaras, etc.

Subfamily Falconinae. Falcons.

FALCO MEXICANUS Schlegel. Prairie Falcon.

Accidental visitant.

The only record of the local occurrence of this falcon is the specimen taken by Bryant in 1887. It may occasionally straggle into the county during its migratory wanderings but there is no further positive evidence of this.

FALCO PEREGRINUS ANATUM Bonaparte. Duck Hawk.

Uncommon migrant.

This pirate among birds was a former summer resident in this vicinity and is known to have nested along the river bluffs.

It has not been often observed of late years, the only available dates being March 29, 1904, May 3, 1908 (specimen), September 18, 1914.

FALCO COLUMBARIUS COLUMBARIUS Linn. Pigeon Hawk.

Uncommon migrant.

There are but ten available authentic records of the local occurrence of this falcon; not enough to show the migration extremes.

It may be looked for about timbered and open country during April and October. It is of only casual occurrence and does not winter here.

[FALCO COLUMBARIUS RICHARDSONI Ridgway. Richardson's Pigeon Hawk.]

Probably a rare migrant.

Though no specimens have been taken, this subspecies is no doubt of local occurrence during migration as it has been reported several times from surrounding territory. It is not easily distinguishable in the field from the Pigeon Hawk and specimens will have to be taken to establish its presence here.

FALCO SPARVERIUS SPARVERIUS Linn.

CERCHNEIS SPARVERIA SPARVERIA (Linn.). Proposed April 1917. Sparrow Hawk.

Very common resident.

This is our commonest and most beautiful hawk and is found

throughout the year, though more numerous during the breeding season. It nests freely within the city, even occasionally in the business district (Hall Bldg. 1916), where it may also be seen in winter feeding on the bountiful supply of English Sparrows. It will nest in any kind of a cavity and should be encouraged to remain by the placing of properly constructed nesting boxes.

The Sparrow Hawk has been proven to be a decidedly beneficial species, as it destroys large quantities of noxious insects and English Sparrows.

Family PANDIONIDAE. Ospreys.

PANDION HALIAETUS CAROLINENSIS (Gmelin). Osprey.

Not uncommon migrant; former summer resident.

The Fish Hawk is seen regularly during April and early May and in September and October. It may be looked for on the Missouri River or about large ponds and lakes. Three were seen over the Lake of the Woods on September 12, 1914, and single birds have been frequently observed there.

The last pair known to have nested in the county was reported by Bryant in 1884. This pair had their nest on the rocks on a high point of the bluffs north of Independence.

The Osprey is said to breed in the bottom timber a few counties to the north.

Suborder **Striges.** Owls.

Family ALUCONIDAE. Barn Owls.

ALUCO PRATINCOLA (Bonaparte).

TYTO ALBA PRATINCOLA Hartert. Proposed October, 1916.

Barn Owl.

Uncommon resident.

Specimens of the Barn Owl taken in this vicinity during May, June and July show that the bird must breed here, and there is one locally taken set of eggs known. Bush and Tindall state that it breeds in the neighborhood of Courtney and Independence.

It may be looked for about open farming country as well as

in orchards and open timbered places. It builds in hollow trees, barns, belfreys and similar places.

Family Strigidae. Horned Owls, etc.

Asio wilsonianus (Lesson). Long eared Owl.

Uncommon summer resident; common migrant and winter resident.

The Long-eared Owl occurs chiefly in the timbered bottoms, both in winter and during the breeding season. Small flocks have often been seen there in late autumn and winter; Bush reports one flock of sixty birds wintering near Courtney. A flock of about thirty are found nearly every winter in the large stand of cottonwood timber across from the mouth of the Big Blue.

Long-eared Owls begin laying their five or six eggs early in March and often refit and reline with feathers for their own use, old nests of crows and squirrels.

Asio flammeus (Pontoppidan). Short-eared Owl.

Fairly common migrant; irregular winter resident; very rare summer resident.

The Short-eared Owl arrives from the north in early or middle October and leaves in March. During open winters when the snowfall is light, flocks of from 8 to 10 to 50 or more may be found wintering where suitable grassy or weedy roosting places are near good hunting ground. Such places are common on the high prairie regions where this owl's favorite game abounds, though the open stretches of grassy bottom lands afford equally good wintering resorts. A flock of 15 or 20 birds spent the winter of 1916-17 in the neighborhood of 63rd Street west of Broadway, where they roosted in a patch of weeds and high grass within a hundred yards of several houses under construction on one side, and a noisy foot-ball field on the other. When flushed from their roosting ground in the high grass, they sail around gracefully like gulls and perch about on fence posts or drop down further on in the grass and sometimes even on the bare ground in plain sight. During these flights they emit a low plaintive cry reminiscent of the Green Heron's note though much less harsh. Several of the stomach pellets collected on this roost were sent to the mammalogists of the National Museum to determine the species of rodent that consti-

tutes the chief diet of the owl. The skulls contained in the pellets belonged to the species *Microties ochrogaster* (Wagner).

During the late fall of 1917, a large scattered flock of these owls were seen in the open bottom country near the mouth of Big Blue, where they remained until well into December. Many hundred acres of newly formed land overgrown with typical sand-bar and lowland vegetation, bordered with thickets of young willows, afforded ideal roosting places. An unusual feature of their stay at this time was their feeding on the Tree Sparrows that frequented the willow thickets in droves. Nearly every pellet opened contained skull, sternum or other token of these small birds. Here is an indictment against this owl not corroborated in the books. The fact of their resorting to this unusual diet, as well as their moving further south before the arrival of very severe weather conditions, may be accounted for by the absence of their favorite rodent prey on this new ground.

The only breeding pair so far discovered in this vicinity was reported by Smithson of Warrensburg during the summer of 1903.

STRIX VARIA VARIA Barton. Barred Owl.

Common resident.

The Barred Owl is a denizen of the woods about the city where it nests in cavities of large trees and where it is present during the entire year. The wooded bottom lands are favorite haunts and even such places as Fairmount Park, Mount Washington, Swope Park and other wooded tracts close in, have harbored nesting pairs of these big owls.

CRYPTOGLAUX ACADICA ACADICA (Gmelin). Saw-whet Owl.

Very rare winter visitant.

Only one specimen of this small owl has so far been reported. One was found dead on Summit Street in 1894 by Bryant.

OTUS ASIO ASIO (Linn.).

OTUS ASIO NAEVIUS Gmelin. Proposed April, 1917. Screech Owl.

Very common resident.

The Screech Owl is a common bird within the city, nesting in early March about the boulevards and parks, wherever suit-

able cavities are to be found. A pair nested for fifteen years at Armour Boulevard and Campbell, another at Valentine Road and Broadway, and others have been regularly seen or heard in many other neighborhoods.

They have been observed lurking about street lights in search of large insects or possibly toads. They are known to prey on mice and English Sparrows and should be carefully protected.

It is doubtful if this owl is as common about the city as formerly, since it is frequently killed or driven away under the impression that it is a destroyer of song birds. One instance is known of six (two adults and four grown young) being killed in one evening.

An examination of dozens of specimens taken in this vicinity leads to the belief that the gray color phase predominates here.

BUBO VIRGINIANUS VIRGINIANUS (Gmelin). Great Horned Owl.

Fairly common resident.

The eight or ten specimens of this big owl in the Swope Park Zoo are said to have been captured within the boundaries of the park.

Great Horned Owls have been found nesting several times in the timber along the Blue and in the Missouri bottoms. Old hawk's nests are sometimes refitted and used, but more often the eggs are laid in natural cavities in trees. The birds begin laying late in January or early in February.

[BUBO VIRGINIANUS PALLESCENS Stone. Western Horned Owl.]

Probably a casual resident.

The presence of this subspecies will no doubt in time be established here as it is known to range much further east. No specimen has yet been taken in this vicinity.

NYCTEA NYCTEA (Linn.). Snowy Owl.

Very rare winter visitant.

This far northern species has been seen here but three times. It ranges thus far south only during the coldest winters. A specimen taken by Jno. Bryant many years ago has been destroyed. There are three specimens in the Dankers collection.

SPEOTYTO CUNICULARIA HYPOGAEA (Bonaparte). Burrowing Owl.

Accidental visitant.

The only specimen of this plains bird known to have been

taken in the State of Missouri was killed by Chas. Dankers on April 19, 1902, at Corning in Holt County.

It may occur occasionally on the prairie regions along the western border of this county, since it has been reported not far to the west.

Order PSITTACI. Parrots, Macaws, Paroquets, etc.

Family Psittacidae. Parrots, Macaws and Paroquets.

Conuropsis carolinensis (Linn.).

Conuropsis carolinensis ludoviciana (Gmelin). Proposed April, 1917. Carolina Paroquet.

Formerly an abundant resident; now extinct.

Narratives of early travel up the Missouri River make frequent mention of the abundance in this locality of this beautiful but noisy bird. The bottom lands were its favorite haunt, since its natural food, the cockle-bur, grew, and still grows, there in great profusion. It ranged in flocks over the surrounding country and was a familiar color note in the landscape.

It is authoratively stated to have nested in hollow trees in the dense forests of the Missouri River flood-plains during the times of its abundance here.

There is a specimen in the Public Library taken by Bryant in 1894. This was no doubt a straggler as Widmann states that the flocks of Paroquets seem to have faded from Missouri with the fifties.

In some unaccountable manner a lone bird strayed into the Courtney bottoms in 1912 and was observed by Bush for several weeks before it finally disappeared.

Order COCCYGES. Cuckoos, etc.

Suborder **Cuculi.** Cuckoos.

Family Cuculidae. Cuckoos, Anis, etc.

Subfamily Coccyzinae. American Cuckoos.

Coccyzus americanus americanus (Linn.). Yellow-billed Cuckoo.

Common summer resident.

The first day of May usually sees the first Cuckoo here from

the south. Between the 15th and 23rd of September the last southward bound birds have generally left, though an individual bird lingers now and then into October. Some exceptionally late dates are October 19, 1893, October 2, 1915, and October 22, 1916.

The nest is a very flimsy affair indeed as the eggs are often visible from beneath through the loosely constructed platform of coarse twigs. Three or four and rarely five greenish eggs are laid sometimes during June.

There are many particulars regarding the life history of this peculiar bird that are worthy of attention; such as their apparent occasional parasitism, the simultaneous bursting of all the feather sheaths of the nestlings, the peculiar and unique mating behavior and their habit of feeding on certain irritating insect larvae that but few, if any, other birds will eat.

COCCYZUS ERYTHROPHTHALMUS (Wilson). Black-billed Cuckoo.
Uncommon migrant and rare summer resident.

The arrival and departure of this cuckoo as well as its nesting habits, behavior and other points of life history are the same as those of the Yellow-billed, though it is far less frequently seen.

A close observer may readily distinguish it in the field from the Yellow-billed. It should be looked for during the breeding season as but scant local nesting data has been secured.

There are but three or four known sets of eggs in local collections that have been taken in this vicinity.

Suborder **Alcyones.** Kingfishers.

Family ALCEDINIDAE. Kingfishers.

CERYLE ALCYON (Linn.). Belted Kingfisher.
Common summer resident and rare winter resident.

A few Kingfishers are found on the streams in late February but they do not become numerous until a week or two later. Only a few remain as late as the last half of November. During open winters an occasional bird has been known to remain all winter near some favorite fishing hole. During the rather severe winter of 1916-1917, when the smaller streams were at times frozen solid, at least two birds were known to have spent

the entire winter near Independence, one on Mill Creek and one on the Little Blue.

The Kingfisher is a familiar bird along the entire length of the Blue River and excavates its nesting burrows in the high banks in and near Swope Park. It is not often found on the Missouri itself, perhaps because the minnows on which it feeds are hatched and spend their early life in the tributaries.

Order PICI. Woodpeckers, etc.

Family PICIDAE. Woodpeckers.

CAMPEPHILUS PRINCIPALIS (Linn.). Ivory-billed Woodpecker.
Former resident; now extinct.

This shy forest bird has long ago disappeared from this locality as well as from the entire state.

Its haunts were in the deep woods of the Missouri bottoms. The species is listed as a former resident on the authority of Judge Guinotte and others.

DRYOBATES VILLOSUS VILLOSUS (Linn.). Hairy Woodpecker.
Fairly common resident.

The Hairy Woodpecker seems to be more numerous in winter than in summer. It is perhaps a little wilder than the following species and is not so often seen in the city. It is also more discriminating in its selection of a nesting site, choosing a less accessible place.

It is present throughout the year and may be looked for in any wooded territory. The eggs are laid late in April or May.

DRYOBATES PUBESCENS MEDIANUS (Swainson). Downy Woodpecker.
Common resident.

The Downy is perhaps our commonest woodpecker and is found everywhere about trees during the entire year.

It is a very confiding bird during severe winter weather and will readily come about the house for any scraps of meat or suet that may be offered. It is also a frequenter of weedy patches during winter and loves to rattle among the dead stalks looking for insect larvae and eggs. It is also a great hunter in orchards and is one of the most beneficial of our common birds.

It should be protected at all times and fed during the most severe periods of winter.

The five or six pure white eggs are laid in April or May in a cavity in some dead limb or post. It is a very pugnacious little defender of its home.

SPHYRAPICUS VARIUS VARIUS (Linn.). Yellow-bellied Sapsucker.

Not uncommon migrant and rare winter visitant.

Migration waves of Sapsuckers, when the birds are to be seen everywhere for a day or two in spring, have been very infrequently observed here. It is better known as a straggler between November and late April.

It is to be looked for about any kind of wooded places and in orchards. Single birds have been occasionally found at any time during the winter.

PHLOEOTOMUS PILEATUS ALBIETICOLA (Bangs). Northern Pileated Woodpecker.

Occasional visitant. Former resident.

This once common woodpecker is still occasionally found in the deep woods of the Missouri bottoms. It persisted as a regular breeder there up until the late eighties or early nineties.

Some more recent dates are: April 30, 1897, November 1, 1915 (Tindall), and March 22, 1916 (Bush). Smithson found a nest with five young near Warrensburg on June 15, 1905, and observed a male bird in the same neighborhood on March 2, 1908.

A few specimens have been brought into the city market during recent years by farmers who invariably shoot this magnificent bird on sight.

MELANERPES ERYTHROCEPHALUS (Linn.). Red-headed Woodpecker.

Very common summer resident; occasional winter resident.

The returning Red-heads arrive during the last few days of April and the bulk of the southbound migrants are gone by the last of September. A few are always about during October, November and less often in December, while an occasional single

bird or small troop may brave the rigors of January and February. A flock of six wintered in the timber near Dodson dur- 1913-1914. Three birds were observed all during the winter of 1915-1916 in the neighorbhood of Kentucky Avenue and Independence Road. A lone bird was observed on Brush Creek near Electric Park in December, 1916, and again about the middle of January, 1917. The presence in winter of this bird seems to depend largely on the crop of shingle oak acorns (Quercus imbricaria Michx.).

The removal by the Park Board of all standing dead trees and the partial doing away with telephone poles has caused this desirable bird to become less common within the city than formerly.

CENTURUS CAROLINUS (Linn.). Red-bellied Woodpecker.

Fairly common resident.

The Red-bellied, unlike several of the other woodpeckers, does not venture far into the city but prefers the more densely wooded outlying country. It is to be found most commonly in the timber along the bluffs and in the bottom lands. It is also found in Swope Park and along the upper Blue.

This bird is rather shy and is more often heard than seen. Its croaking note is very similar to that of the Red-head.

Three or four eggs are laid in April or early May.

COLAPTES AURATUS LUTEUS Bangs. Northern Flicker.

Very common resident, abundant in migration.

This ground-feeding woodpecker is one of the most familiar birds of the city lawns. It is not uncommon in winter but by the first few days of April the migrants are here in great abundance. The southward movement is noticeable all through September.

Flickers begin laying early in May, a full clutch being six or seven eggs. They nest freely in the proper kind of nest boxes.

COLAPTES CAFER COLLARIS Vigors. Red-shafted Flicker.

Rare visitant during migration or in winter.

This locality lies just outside or possibly on the extreme edge of this bird's range. The known instances of its occurrence

here seem to be of enough interest and importance to warrant giving them in detail. They are:

1872. Bryant. One specimen taken.
Dec. 29, 1889. Bush. A flock seen, one specimen taken.
Dec. 12, 1893. Tindall.
Nov. 10, 1899. Tindall.
Sept. 20, 1902. Tindall.
Oct. 25, 1902. Tindall. A small flock seen and one specimen taken.
Jan. 4, 1914. Harris. One seen.
Nov. 5, 1915. Tindall. Flock of six seen and one specimen taken.
Nov. 7, 1915. Hoffmann. One seen.
Nov. 13, 1915. Bush. Flock of five seen and one specimen taken.
Jan. 10, 1916. Bush. A small flock seen.
Apr. 16, 1916. Hoffmann. One bird seen.

Students should be on the lookout for this striking bird.

Order MACROCHIRES. Goatsuckers, Swifts, etc.

Suborder **Caprimulgi.** Goatsuckers, etc.

Family CAPRIMULGIDAE. Goatsuckers, etc.

ANTROSTOMUS CAROLINENSIS (Gmelin). Chuck-will's-widow.

Accidental visitant.

On May 3, 1918, at about dusk, a Chuck-will's-widow flew into the yard of Prof. A. E. Shirling, near Swope Park, and sang several times. The bird was not over fifteen feet from the professor, who distinctly saw it and noted its size as it flew off. This is the first and only known instance of the local occurrence of this bird. Its normal range in western Missouri does not extend much further north than from eighty to one hundred miles to the south of Jackson County.

ANTROSTOMUS VOCIFERUS (Wilson).

SETOCHAILCIS VOCIFERA VOCIFERA (Wilson). Proposed April, 1917. Whip-poor-will.

Common summer resident.

The Whip-poor-will arrives from the 15th to 19th of April and leaves in October. It lays its two beautifully marked eggs

on the bare ground in dense growths of scrub oak or in second growth timber on burnt over hillsides. Three sets in the Tindall collection were taken on the following dates: May 7, 1901, May 20, 1903, June 12, 1915.

It is numerous about Swope Park and Dodson and along the river bluffs.

PHALAENOPTILUS NUTTALLI NUTTALLI (Audubon). Poor-will.

Formerly a rare summer resident.

Bush reports that the Poor-will formerly nested on the open country near Swope Park and Dodson. He frequently heard the mournful cry of this bird in the neighborhood of Grandview. Efforts to find the Poor-will in this county during the summers of 1916 and 1917 proved unsuccessful, though it may yet be found still occasionally breeding on the prairie regions of southern Jackson County.

CHORDEILES VIRGINIANUS VIRGINIANUS (Gmelin). Nighthawk.

Abundant migrant and fairly common summer resident.

The first Nighthawks arrive usually on the 26th, 27th or 28th of April followed by great numbers of migrants during the next three or four weeks. The southward moving flocks pass through during September and early October.

Like other members of this family the Nighthawk builds no nest but lays its two eggs on the bare ground or rocks or on the flat roofs of the tall buildings in the business district of the city. As a breeder it is found chiefly along the northern boundary of the county but ranges out over the prairie country to feed. It is probable that it may nest along the rocky ledges in the Swope Park district.

CHORDEILES VIRGINIANUS HENRYI Cassin. Western Nighthawk.

Regular but not numerous migrant.

Resting flocks of migrating Nighthawks have often been seen to contain birds of varying degrees of pallidity. Some of the individuals are only slightly lighter in color than the native birds while others are so very decidedly lighter that they can be distinguished as far as the flock is visible. There is very little doubt that these forms are the Western and Sennett subspecies but it would be well to take specimens.

All three of these Nighthawks have been observed in Swope Park.

CHORDEILES VIRGINIANUS SENNETTI Coues. Sennett's Nighthawk.

Regular but not numerous migrant.

See the remarks on the Western Nighthawk.

Suborder **Cypseli.** Swifts.

Family MICROPODIDAE. Swifts.

Subfamily Chaeturinae. Spine-tailed Swifts.

CHAETURA PELAGICA (Linn.). Chimney Swift.

Very common summer resident.

The forerunners of the hosts of migrating Chimney Swifts arrive between the 11th and 18th of April. Some exceptionally early dates are: April 8, 1900, March 20, 1903, March 30, 1913, and March 15, 1913.

The southward moving flocks pass from late in August to early October. During this period the Swifts resort to common roosts and may be seen circling in immense funnel-shaped flocks over large chimneys and about towers, such as several of the public school buildings, the Calvary Baptist Church and the old power-house stack at 8th Street and Woodland.

Suborder **Trochili.** Hummingbirds.

Family TROCHILIDAE. Hummingbirds.

ARCHILOCHUS COLUBRIS (Linn.). Ruby-throated Hummingbird.

Common summer resident.

The early Hummingbirds arrive around April 27th, but are not found in numbers until a week or more later. They leave in October.

The nest, a soft, delicate, cottony cup, decorated with lichens, is one of the wonders of avian architecture and is usually saddled on a small horizontal limb ten to fifty feet from the ground. It is often found in orchards.

Order PASSERES. Perching Birds.

Suborder **Clamatores.** Songless Perching Birds.

Family TYRANNIDAE. Tyrant Flycatchers.

TYRANNUS TYRANNUS (Linn.). Kingbird.

Common summer resident.

The first Kingbirds arrive between the 18th and 26th of April, followed during the next ten days by swarms of migrants. The return flight is noticeable as early as the 29th of August and continues for about three weeks.

This flycatcher is fairly common within the city and is a familiar bird everywhere in the surrounding country.

A favorite roosting place for great numbers during the period of flocking that precedes migration is in the miles of willow bottoms along the Missouri River below the Milwaukee Bridge.

TYRANNUS VERTICALIS Say. Arkansas Kingbird.

Occasional visitant during migration and summer.

An unusual visitation of Arkansas Kingbirds occurred on the Dankers' farm in Holt County during the late summer of 1917 when nine specimens were recorded. Prior to this time there were but two known records for this region: May 31, 1899, and May 9, 1913, both specimens being taken by Dankers. There are but three other known records for the entire state of Missouri.

MYIARCHUS CRINITUS (Linn.). Crested Flycatcher.

Very common summer resident.

The Crested Flycatcher arrives from the 23rd to 28th of April (in the following years it arrived promptly on the 27th of April: 1899, 1900, 1901, 1904, 1916 and 1917). An exceptionally early date for this bird was April 15, 1915. (See table of arrival dates given under the Phoebe). It leaves for the south during the first week or ten days in September.

This noisy bird comes freely into the city to nest in cavities in trees or in bird boxes. It has a very sharp eye for cast snake skins which it usually includes in the nesting material. In the city bits of thin or greasy paper or onion skins are substituted.

The eggs, laid in June, are four to seven in number and beautifully marked with streaks and wavy lines.

It may be looked for in all wooded parts of the county.

SAYORNIS PHOEBE (Latham). Phoebe.

Common summer resident.

The Phoebe arrives during the first half of March, though exceptionally severe weather may delay the vanguard for a week or more. The following arrival dates will show the irregularity of its arrival contrasted with the regularity of the foregoing species.

Sayornis phoebe.	Myiarchus crinitus.
March 3, 1893.	
March 11, 1894.	
March 23, 1895.	April 28, 1895.
March 29, 1896.	April 25, 1896.
March 15, 1897.	April 25, 1897.
March 13, 1898.	April 30, 1898.
March 14, 1899.	April 27, 1899.
March 11, 1900.	April 27, 1900.
March 12, 1901.	April 27, 1901.
March 11, 1902.	April 24, 1902.
March 8, 1903.	April 22, 1903.
March 26, 1904.	April 27, 1904.
March 15, 1907.	
March 7, 1908.	
March 21, 1909.	
March 13, 1910.	
March 18, 1911.	May 3, 1911.
March 30, 1912.	May 1, 1912.
March 30, 1913.	May 3, 1913.
March 13, 1914.	April 23, 1914.
March 8, 1915.	April 15, 1915.
March 12, 1916.	April 27, 1916.
March 14, 1917.	April 27, 1917.

The last southbound Phoebes are seen about the middle of October. The cry of this bird is a familiar note about culverts, bridges, mossy ledges near streams, and farm outbuildings. It does not venture far into the city but is common in the surrounding country.

Its five or six eggs are laid during the latter part of April, usually from the 19th to 27th. A very early date was April 7, 1908 (five eggs).

NUTTALLORNIS BOREALIS (Swainson). Olive-sided Flycatcher.

Rather rare migrant.

A few migrating Olive-sided Flycatchers are present during late May and early June and again in early September. It is more often heard than seen and is to be looked for in the tops of tall, often dead, trees along water courses. It may be readily identified by its loud, wild and distinctive whistle.

MYIOCHANES VIRENS (Linn.). Wood Pewee.

Rather uncommon summer resident.

The Wood Pewee arrives early in May and leaves in late September. It is a woods-loving bird, and is found within the city only in the more secluded and heavily wooded sections, such as Swope Park.

The nest is a very beautiful structure composed of fine materials such as lint and cottony substances. It is saddled onto a limb, usually a dead one, after the fashion of a Hummingbird's or Gnatcatcher's nest. The Wood Pewee begins laying about the first of June.

EMPIDONAX FLAVIVENTRIS (W. M. & S. F. Baird). Yellow-bellied Flycatcher.

Rather rare migrant.

The Yellow-belly may not be as rare during migration as the few records seem to show, since it is a difficult bird to find. It frequents dense undergrowths and thickly grown-up bottom and bluff regions and is usually silent. It is present during the last half of May and early June (six records). There are no autumn records for this county, but a specimen was taken about thirty miles to the west on September 15, 1908, by Bunker (Kansas University Museum).

EMPIDONAX VIRESCENS (Vieillot). Acadian Flycatcher.

Somewhat common summer resident.

The Acadian or Green Crested Flycatcher arrives during the first few days of May and is present until the middle of September.

It is never found outside of thickly wooded places. Its favorite haunts are the wooded ravines of the bluff regions and wherever creeks flow through timber. Two or three pairs nest regularly in Shilo Hollow, near Swope Park, and several are always to be found during summer in Hazel Dell, a secluded creek bot-

tom above the Lake of the Woods. There are probably many such places in the central and eastern parts of the county where this and other shade-loving species are to be found.

The eggs are laid from the last few days in May to the middle of June.

Besides the song (wick-y-up) and the sharp call note, the bird often utters a humming or murmuring note which seems to be known to but few observers.

EMPIDONAX TRAILLI TRAILLI (Audubon). Traill's Flycatcher.

Fairly common migrant and rare summer resident.

The Traill's Flycatcher arrives early in May and leaves during September. Its favorite haunts are in creek or river timber, though it is found also in the parks and about the outskirts of the city in orchards and wooded tracts. Thickets and open woods also attract it, and a few are always to be found in late May about the extensively planted estates in the neighborhood of 52nd and Oak. The best time to observe this flycatcher is during the last two weeks of May when the bulk of the northbound migrants are present.

There are no records available of the Traill's Flycatcher breeding in Jackson County, but, judging from its distribution as a summer resident in Missouri, it probably will be found nesting in thickets about sloughs and along river courses in this vicinity.

EMPIDONAX TRAILLI ALNORUM Brewster. Alder Flycatcher.

Rare migrant.

This subspecies has not yet been satisfactorily worked out for this county owing to lack of material, only one specimen having been taken. It has been taken in enough numbers both to the east and west to warrant the belief that there can be little doubt as to its regular occurrence here. The difference between the two forms is one of size only and a series of local specimens will have to be studied before much is known.

EMPIDONAX MINIMUS (W. H. & S. F. Baird). Least Flycatcher.

Common migrant and very rare summer resident.

The Least Flycatcher arrives from April 30th to May 6th and leaves during September.

The only authentic record of the Chebec having nested in the State of Missouri is furnished by Tindall, who took a set of

three eggs in this county on June 16, 1891. This same collector has taken specimens of the bird here during the nesting season, but only this one nest has been found.

Suborder **Oscines.** Song Birds.

Family Alaudidae. Larks.

Otocoris alpestris alpestris (Linn.). Horned Lark.

Regular but not numerous winter visitant.

A few flocks of Horned Larks visit this vicinity during winter, scattering over the prairie regions and the sandy bottom lands. They are usually in the company of *praticola* and may be distinguished by their larger size and darker color. A few specimens have been taken in this vicinity.

Otocoris alpestris praticola Henshaw. Prairie Horned Lark.

Common resident and very common migrant.

The Prairie Horned Lark is found throughout the year, either in the open country of the bottom lands or more numerously in the prairie regions. It is the commonest bird in the early wheat fields. Its song may be heard on mild days in January. It is an early breeder, the eggs having been found as early as March 20th, and the nest is often covered with snow.

[Otocoris alpestris hoyti Bishop. Hoyt's Horned Lark.]

Probable winter visitant.

This large pallid form has not yet been taken in the county, but may occasionally occur here during winter. Students should be on the lookout for it.

Family Corvidae. Crows, Jays, Magpies, etc.

Subfamily Garrulinae. Magpies and Jays.

Pica pica hudsonia (Sabine). Magpie.

Formerly a very rare winter visitant.

There is a specimen of this bird in the collection of Dr. Cunnington of Tarkio, Missouri, taken in the Missouri River bottoms of Holt County late in the fall of 1913. One specimen has been taken near Lawrence (Snow). Four birds were observed in Saline County (two counties to the east, on the river) by L. W. Corder (Widmann).

The Magpie has become rare of late years in its habitat in the northwest, but an occasional straggler may still find its way down the Missouri Valley during severe winters.

CYANOCITTA CRISTATA CRISTATA (Linn.). Blue Jay.

Very common summer resident; not uncommon winter resident.

Flocks of migrating Jays move through this district on their northward flight from the 15th of April to the 5th of May and on the southward journey during the first half of October. A route much used by these migrants is along the Missouri bluffs and lowlands.

During some winters Jays are to be found in numbers, even in the city, but during others are very scarce. During the rather severe winter of 1916-1917, few Jays were to be found anywhere but in Sowpe Park.

Jays nest early in May and more than one brood is raised.

Subfamily Corvinae. Crows.

CORVUS CORAX SINUATUS Wagler. Raven.

Former resident.

In the late seventies the Raven nested in the rocky bluffs overlooking the Missouri River in this county. It was formerly common, but has become extinct in this part of the country. A few are still said to breed in this state in the Ozarks.

CORVUS BRACHYRHYNCHOS BRACHYRHYNCHOS Brehm. Crow.

Common resident and abundant migrant.

Crows are to be found everywhere in the county, but are most abundant in the Missouri Valley, where they occur in the greatest numbers in winter. There is always a large winter roost somewhere in the vicinity of the Big Eddy or the mouth of Sugar Creek or the Blue River, usually on the Clay County side. Great numbers nest in April in the bottom timber as well as in Swope Park and other heavily wooded places over the entire county.

NUCIFRAGA COLUMBIANA (Wilson). Clarke's Nutcracker.

Accidental visitant.

On October 28, 1894, a specimen of this bird was taken near the city by Bryant. The bird was far off its range and is to be

considered as purely an accidental visitant. There are but three or four other records for surrounding states.

Family Icteridae. Blackbirds, Orioles, etc.

Dolichonyx oryzivorus (Linn.). Bobolink.

Rather rare migrant.

Bobolinks are occasionally present in small flocks during the first half of May and again during September. They sometimes occur on the prairie regions, but more commonly in the Missouri Valley. They are sometimes heard migrating at night when they may be readily distinguished by their characteristic "pink." They are usually in song on the northward flight, but on the return are silent save for the "pink, pink."

Molothrus ater ater (Boddaert). Cowbird.

Very common summer resident; occasional winter resident.

Though an occasional Cowbird is seen during the winter months, usually in the company of blackbirds, the earliest migrants do not arrive until the first or second week in March and the bulk of the flight not until a week or two later. The autumn migration is at its height during late September and early October.

The Cowbird is generally distributed over the entire county and is fairly common within the city. Whenever the eggs of this parasitic species are found in the nests of more desirable song birds they should be destroyed, as the young are a menace to the young of the host species.

Xanthocephalus xanthocephalus (Bonaparte). Yellow-headed Blackbird.

Not very common migrant and rare summer resident.

The Yellow-headed Blackbird arrives during the second week of April and is rarely seen after October. It is to be found on the prairie regions during migration, but occurs in greater numbers in the Missouri bottom lands and on the farming country near the bluffs. It is probably not as common as formerly, and does not breed as freely in this county. It nests in colonies about the river lakes in several of the up-river counties, as at Bean Lake and at Armour.

AGELAIUS PHOENICEUS PHOENICEUS (Linn.).

AGELAIUS PHOENICEUS PREDATORIUS (Wilson). Proposed April, 1917.

Common summer resident; very abundant migrant; irregular, sometimes not uncommon winter resident.

DISTRIBUTION OF A. P. PREDATORIUS

Continuous line encloses breeding range.
Broken line shows extent of winter range.

Immense hordes of Red-wings migrate up and down the lowlands bordering the Missouri River. Flocks numbering untold thousands are present during spring and autumn, and occasional birds are found among the wintering throngs of Thick-bills and Northern Red-wings. The earliest flocks, composed almost entirely of males, begin to arrive during the first few days of March while the wintering birds are still present in some numbers. In favorable winters this northward movement may start as early as the middle of February. Not until the first of May have the last flocks of late females passed, leaving only the breeding birds present. These summer residents may be looked for in the bottom lands or on the uplands about swampy places, or where there are reeds, rushes, high grass or cat-tails near water. They start nesting about the middle of May. Flocking begins as early as the middle of July when the birds begin to

use common roosts in the bottoms, scattering over the entire county at early dawn to feed. The southward movement commences early in October and continues until well into December.

AGELAIUS PHOENICEUS FORTIS Ridgway. Thick-billed Red-wing.

Irregular, sometimes very abundant, migrant and winter resident.

DISTRIBUTION OF A. P. FORTIS

Continuous line encloses breeding range.
Broken line shows extent of winter range.

The Red-wings wintering in this vicinity were long suspected of belonging to this very noticeably larger subspecies, but prior to the winter of 1916-1917 no systematic investigation had ever been made in western Missouri to establish their subspecific status. This rather severe winter proved to be a favorable one for this study, as the birds were present in unusual abundance. A large series of specimens was taken over a wide area and covering the entire period of their sojourn.

They began arriving in small numbers during the middle of November and continued coming in increasing numbers until during the intense cold periods of late December and January there were countless thousands resorting to common roosts in the timbered bottoms along the Missouri River. In the early mornings when the birds scattered to feed, great flocks flew over

the city to their feeding grounds on the prairie regions many miles to the south and west. It is estimated that some of the flocks covered daily from thirty to fifty miles on these journeys.

As early as the middle of February much singing and mating activity was noted among the flocks and the ranks were beginning to thin. On March 2nd the last specimens of *fortis* were taken (from large masses of birds), and by March 5th this form had been almost entirely replaced by equally large flocks of *predatorius*. Several specimens taken on this date from large flocks proved to be referable to the breeding form. A difference was also noted in the music of the flocks, as the notes of *fortis* are softer, more melodious and less grating than those of *predatorius*.

These northwestern birds do not seem to have passed down the Missouri Valley (east) beyond this point, as only an occasional bird was seen in the nearby down-river counties.

The stomachs of ten males and one female taken from one flock on January 17th contained large quantities of the seeds of sorghum (*Sorghum* sp.) and knotweed (*Polygonum lapathifolium* L.).

Very few Northern Red-wings (*A. p. arctolegus*) were present during this hard winter, though during the equally severe winter of 1917-1918 this form greatly predominated.

AGELAIUS PHOENICEUS ARCTOLEGUS Oberholser. Northern Red-wing.

Abundant migrant; irregular, sometimes very common winter resident.

Large moving masses of this recently described subspecies are not readily distinguishable in the field from the Thick-bill, and may even be mistaken for the breeding form unless seen at close range or in mixed flocks. Not enough material has yet been secured to give with certainty the dates of its arrival from the north in the fall or the limits in time of its passage through here on the return in spring. Great hordes pass during both seasons and varying numbers are present during the entire winter. All three forms intermingle here in winter, as, on at least one occasion, specimens of all three have been taken from the same flock.

The accompanying map shows that this region lies fairly in the center of the migratory path of this race, and on the edge of its winter range.

DISTRIBUTION OF A. P. ARCTOLEGUS

Continuous line encloses breeding range.
Broken line indicates extent of winter range.

STURNELLA MAGNA MAGNA (Linn.). Meadowlark.

Common summer resident and very common migrant; rather rare winter resident.

Small troops of returning migrants begin to arrive from the 25th to the last of February, but are not numerous until about the middle of March. The southbound migration wave passes in October. Only a few birds, sometimes none, are to be found here in winter.

The Meadowlark is generally distributed over the entire county and breeds everywhere in favorable open grassy places, even coming into the outskirts of the city to nest. It begins laying early in May.

STURNELLA NEGLECTA Audubon. Western Meadowlark.

Regular but uncommon summer resident.

Typical examples of the Western Meadowlark are found here and there on the prairie regions of the county. Several pairs nest regularly in the Country Club district and about Waldo.

Breeding birds have been seen near Dodson, Grandview and further west and south. They formerly nested in the neighborhood of Swope Park, but none have visited that district in several years with the exception of one pair that raised a brood near 41st and Benton Boulevard during the summer of 1917.

Occasionally Meadowlark songs are heard that are intermediate between the two forms.

ICTERUS SPURIUS (Linn.). Orchard Oriole.

Common summer resident.

The first Orchard Orioles may be looked for between the 25th and 30th of April. They seldom fail to arrive some time during these five days. The only two known earlier dates are April 22, 1897 (Tindall), and April 19, 1909 (Smithson).

Great numbers of migrants are often seen resting in the willow thickets in the Missouri bottoms during the first eight or ten days of May. They start south late in August and after about ten days only stragglers are seen.

The Orchard Oriole may be found in all parts of the county and nests freely within the city in favorable districts. Its four to six eggs are laid in late May or early June.

ICTERUS GALBULA (Linn.). Baltimore Oriole.

Common summer resident.

The Baltimore Oriole usually arrives a few days earlier than the Orchard Oriole and is perhaps more numerous in the city, at least. Its wonderful nest is suspended from the overhanging extremities of the limbs of shade trees, preferably elms, in all residence districts.

It is about equally common in the outlying country and often builds there in sycamore and cottonwood trees. The four or five eggs are laid in May.

During the period of moult in late July and early August the Orioles are silent and secretive and are seldom seen. Prior to their departure for the south they have another period of song.

EUPHAGUS CAROLINUS (Muller). Rusty Blackbird.

Not uncommon migrant; rare winter resident.

The first Rusty Blackbirds arrive on their journey to the northern breeding grounds sometimes as early as the third week

in February, but more often during the second or third week in March. A flock numbering over two thousand birds was seen on February 21, 1916. By April 15th only stragglers are seen. The southward flight passes through in October, tapering off into November. A few birds may be found here during mild and open winters.

EUPHAGUS CYANOCEPHALUS (Wagler). Brewer's Blackbird.

Rare migrant.

Three sight records of this bird constitute the only known evidence of its occurrence here. Since the Brewer's Blackbird may be easily mistaken in the field for the Bronzed Grackle, it may often go unnoticed in flocks of the latter. It has been observed on the prairie regions of Jackson County once, and in the bottoms twice, but no specimens have been taken. It is very desirable to obtain more data relative to this species, as well as more satisfactory proof of its local occurrence. Its migration through this region is probably coincident with that of the Rusty Blackbird.

QUISCALUS QUISCULA AENEUS Ridgway. Bronzed Grackle.

Common summer resident.

A few hardy and impatient Grackles sometimes arrive late in February, but it is usually mid-March before many are present. The bulk of the flight arrives still later, during late March and the first week in April. The return migration occupies October and early November and a few may be present until well into December.

Grackles are very common within the city, where their habit of occupying common roosts in shade trees, usually over sidewalks, makes them a great nuisance. These roosts are not easily broken up and many residents of the south side of the city have had trying experiences in ridding their neighborhoods of this pest. The most effectual method is to shoot Roman-candles into the trees after the birds have settled for the night.

Family FRINGILLIDAE. Finches, Sparrows, etc.

HESPERIPHONA VESPERTINA VESPERTINA (W. Cooper). Evening Grosbeak.

Very rare and irregular winter visitant.

Only during occasional winters is this district invaded by

Evening Grosbeaks. The last visitation occurred in 1911, when several flocks of from two to twenty-five were seen at widely separated points in this vicinity. The first were noted on January 23rd, after which they were present until the 6th of May. None have been seen since that year.

CARPODACUS PURPUREUS PURPUREUS (Gmelin). Purple Finch.
Rather common migrant; not uncommon winter resident.

Flocks of migrating Purple Finches are likely to be seen any time between February and late April and again during October and November. Small groups of wintering birds have been seen in December and January in all parts of the county, notably in such places as Swope Park, the Country Club district, the upper Blue Valley and along the Missouri bluff regions.

LOXIA CURVIROSTRA MINOR (Brehm). Crossbill.
Rather irregular but sometimes not uncommon winter resident.

Only an occasional winter passes without at least a few Crossbills being seen. During rare winters thousands (Bush) are present and are to be found wherever there are suitable feeding places. They are attracted by sunflower patches, orchards where fruit has been left hanging, pine trees and weed patches. They have also been seen tearing to pieces the fruit of the Osage orange. Crossbills may be looked for between late October and early May.

LOXIA LEUCOPTERA Gmelin. White-winged Crossbill.
Very rare winter visitant.

There is only one authentic record of the occurrence of this Crossbill in this vicinity, though it probably occurs occasionally in the company of the other species.

Students should be on the lookout for this bird, as we are well within its winter range.

ACANTHIS LINARIA LINARIA (Linn.). Redpoll.
Very rare winter visitant.

Only three records are known of the occurrence of the Redpoll here; February 21, 1882; January 14, 1906, and February 13, 1916.

ASTRAGALINUS TRISTIS TRISTIS (Linn.). Goldfinch.

Very common summer resident; not uncommon winter resident.

The Wild Canary or Thistle Bird is most abundant here during migration, from the last week in April to the middle of May and during October. They are always present in winter in varying abundance and are generally distributed over the entire county.

They nest rather late, as is shown by the following data from the Tindall collection:—August 21, 1891, four eggs; August 21, 1891, six eggs; June 30, 1895, three eggs; September 7, 1902, five eggs.

The male Goldfinch presents a good example of the plumage change in birds whose summer and winter coats are entirely different. Individuals may be seen during different seasons of the year in all phases of their changing color.

SPINUS PINUS (Wilson). Pine Siskin.

Not uncommon migrant and winter visitant.

A large per cent of the flocks of wintering Goldfinches have Siskins scattered among them. They are easily distinguished by their notes and by the streaked plumage.

Flocks of migrating Siskins numbering hundreds have been seen between the middle of March (March 11, 1907) and the last of April, and from the last week of October to middle or late November.

The presence of this bird in winter is often overlooked and every group of Goldfinches and wintering Sparrows should be closely scrutinized to find it.

PASSER DOMESTICUS (Linn.).

PASSER HOSTILIS Kleinschmidt. Proposed October, 1916. English Sparrow.

Very abundant resident.

This alien species has established itself not only about the centers of civilization but has overflowed into the surrounding wild places and has proven itself equally successful in leading a feral existence. It is found in the wildest and most inaccessible tangles of the Missouri bottom jungles, and nests in vines in the timber along the water courses and in deserted woodpecker holes as well as natural cavities. Under favorable con-

ditions as many as four broods are brought forth in a single year.

It is probably a fact that the balance of nature will be adjusted in time by this sparrow at the expense of our more desirable native forms, though this may be partially compensated for by an increase in the smaller predatory birds, but as far as the writer has been able to observe no appreciable harm has as yet been done—at least in this vicinity.

Mr. Widmann writes that the zenith of this bird's abundance has been reached in St. Louis several years ago, and is of the opinion that the late severe winters and lack of suitable nesting sites may have caused this standstill or decrease. This condition has also been noted in Kansas City, though coincident with the decrease within the city there has been a most decided increase in the surrounding rural districts.

PLECTROPHENAX NIVALIS NIVALIS (Linn.). Snow Bunting.

Very rare and irregular winter visitant.

This wanderer from the north reaches this vicinity only during the most severe winters. On January 29, 1889, a flock of several dozen of these beautiful birds was observed at Courtney by Bush. There is a specimen in the Tindall collection taken near Independence on November 8, 1892.

CALCARIUS LAPPONICUS LAPPONICUS (Linn.). Lapland Longspur.

Regular and not uncommon winter resident, sometimes very common.

Lapland Longspurs are to be looked for on the prairie regions of the county between the first week in November (November 5, 1913, earliest) and the middle of March (March 18, 1917, latest).

Small flocks are commonly met with between the Country Club and the upper Blue Valley, but very seldom visit the Missouri Valley.

During some winters, flocks of hundreds are present, and during migration thousands are heard passing over at night.

CALCARIUS PICTUS (Swainson). Smith's Longspur.

Very rare and irregular winter visitant.

The one local record for this bird is May 1, 1905, when three specimens were taken. It is reported as a common winter so-

journer in Kansas, is a regular migrant in Illinois and winters regularly in Arkansas. It therefore should be looked for in this vicinity.

CALCARIUS ORNATUS (J. K. Townsend). Chestnut-collared Longspur.

Rather rare winter visitant.

This bird has been noted during the winter months on the prairie regions of this county and also in the neighborhood of Warrensburg (Scott). It is occasionally seen in the company of Lapland Longspurs, from which it is readily distinguishable. It is not so easily distinguished from the Smith's Longspur.

[RHYNCHOPHANES MCCOWNI (Lawrence). McCown's Longspur.]

Probable migrant and winter resident.

This Longspur can scarcely be distinguished in the field from the Chestnut-collared. Though there can be little doubt of its more or less regular occurrence here, as specimens have been taken on all sides of us, there is no positive evidence yet at hand that it visits Jackson County. The species should be looked for.

POOECETES GRAMINEUS GRAMINEUS (Gmelin). Vesper Sparrow.

Fairly common migrant; very rare summer resident.

The Vesper Sparrow arrives from the south about the first of April (March 31, 1895; March 23, 1916, earliest) and is no longer present after the 20th to 25th of the month. It is here again during October and has never been seen later than November 5th. Though there are two or three summer records, it is not considered a regular breeder in this vicinity.

The Vesper Sparrow is found in open fields or along grassy hillsides covered with open groves. It is about intermediate in its choice of cover between the Savannah Sparrow of the open prairie and the Song Sparrow which never moves far from thick shelter. Some very good sparrow haunts are to be found in and about Swope Park.

PASSERCULUS SANDWICHENSIS SAVANNA (Wilson). Savannah Sparrow.

Common migrant and very rare and irregular summer resident.

The Savannah Sparrow arrives during the middle of March and is common until the third week in April. There are a few

known instances of its remaining during the entire summer. The nest has never been found in the county. The first southbound migrants have been noted as early as September 26th and the species is common again during the first three weeks of October. All are gone by the end of the first week in November.

Savannah Sparrows may be found anywhere in the county in weedy fields, open bottom lands and on the prairies.

PASSERCULUS SANDWICHENSIS ALAUDINUS Bonaparte. Western Savannah Sparrow.

Migrant, probably not rare.

Three specimens of this subspecies taken by Teachenor near Lawrence, and one taken by Tindall near Independence, constitute the only available records on which to base an estimate of the comparative abundance here of the two forms of the Savannah Sparrow. That the western form is a regular migrant through Jackson County, there can be little doubt, since it has been frequently taken east of here, and is considered common about Lawrence.

AMMODRAMUS BAIRDI (Audubon). Baird's Sparrow.

Very uncommon migrant.

But two known specimens of Baird's Sparrow have been taken in this vicinity (Wilson, Buchanan County), though it may often occur in the company of other migrating sparrows, especially in the large flocks to be found in the Missouri bottoms. This district lies within the migratory path of this sparrow.

AMMODRAMUS SAVANNARUM AUSTRALIS Maynard. Grasshopper Sparrow.

Very common migrant; irregular, sometimes not uncommon summer resident.

The Grasshopper Sparrow arrives about April 25th, and after the middle of May only breeding birds are present. The last have left by early October. In some years none seem to remain to breed, but in others, as during the summer of 1918, many pairs may be found in suitable localities.

This sparrow is to be found chiefly on the prairie regions in high grass and in clover fields. It is a common visitor to the

meadow in Swope Park, where it sometimes breeds, and along the Missouri Pacific right-of-way in the upper Blue Valley, where there is much red clover.

The weak, high-pitched, insect-like notes of this little skulker more often attract attention to it than an actual sight of the bird.

AMMODRAMUS SAVANNARUM BIMACULATUS Swainson. Western Grasshopper Sparrow.

Rare migrant.

The study of a more extensive series of Grasshopper Sparrow specimens than is yet available will be necessary in order to determine the local abundance of the western form. Only one specimen (Teachenor, Lawrence, Oct. 14, '16) has been examined. Further collecting may establish this subspecies as a regular migrant in this region.

PASSERHERBULUS HENSLOWI HENSLOWI (Audubon). Henslow's Sparrow.

Not uncommon migrant; rather uncommon summer resident.

The Henslow's Sparrow arrives usually during early April (March 28, 1916, earliest) and leaves during October. It nests about marshy places and wet meadows and in damp grassy places. It has been frequently observed in the alfalfa field in Swope Park, on the Armour stock farm, about Lake City and has been found nesting near Independence. It is one of the runners in the grass that may be easily overlooked.

PASSERHERBULUS LECONTEI (Audubon). Leconte's Sparrow.

Common migrant.

The first movement of Leconte's Sparrows into the county is usually noticeable in late February (Feb. 25, 1916; Feb. 25, 1917), but they are not numerous until two weeks later. By the 15th to 20th of April they are gone, not to be seen again until late September. They remain until well into December (Dec. 19, 1896, latest).

These little sparrows are found on the high grassy prairies as well as in the open grassy bottom lands. They are not so easily overlooked as some of their more skulking kin, though they are great hiders and runners through the grass.

CHONDESTES GRAMMACUS GRAMMACUS (Say). Lark Sparrow.

Fairly common summer resident.

The Lark Finch may be expected from the 19th to 28th of April (April 10, 1892, earliest), remaining until late September. It is generally distributed over the entire county near the ledges, or barrens above the streams, where the soil is thin and there are small scattered trees. It may be looked for on the farming country adjacent to the bluff regions and in the upper Blue Valley. It is rather rare in Swope Park, though one pair nested on the rifle range in June, 1917.

The Lark Sparrow is a ground nester and lays its eggs late in May. It is a beautiful songster and a conspicuously marked bird and may not be easily overlooked.

ZONOTRICHIA QUERULA (Nuttall). Harris's Sparrow.

Very common migrant; fairly common winter resident.

So far as the writer is aware, the district embraced in this list has given to science but two birds; namely, the Harris's Sparrow and the Bell's Vireo. Harris's Sparrow may properly be called Jackson County's own bird, since it was discovered here, very possibly within the present corporate limits of Kansas City itself. In late April, 1834, Thomas Nuttall, who with Townsend was making a transcontinental journey in the interest of science, discovered, "a few miles west of Independence," on the road to Westport, a new bird which he named the Mourning Finch. Not until 1840, when Volume 1 of the second edition of his "Manual of the Birds of the United States and Canada" was published, did he describe the finch and give it its systematic name. The fact of a later vernacular name becoming current is traceable to an oversight of Audubon, who, not knowing of Nuttall's discovery, thought he had found a new bird near Leavenworth on his memorable trip up the Missouri River in 1843. He named the bird in honor of his much esteemed friend and companion on the trip, Edward Harris, which name has been recognized by the American Ornithologists' Union and thus made permanent.

The Harris's Sparrow makes its first appearance here late in the first week of October and is present in varying abundance until late in November, after which only the wintering birds are to be found. If the winter be exceptionally severe, as in

1916-17 and 1917-18, only a few hardy birds remain to find shelter in the dense cover of the Missouri bottom undergrowth. During open and mild winters a few may be found in the hedges and weed patches of the prairie country.

The northward movement begins late in February, but is not marked by the characteristic waves, when great numbers are here today and gone tomorrow, until three or four weeks later. The Harris's Sparrow usually disappears by the first of May, though during late seasons it may remain until the second or third week (May 17, 1916; May 11, 1913, common).

The notes of this handsome sparrow are querulous and pitched in a minor key and though very similar to those of their traveling companions, the White-throats, are readily distinguished from them by the absence of a well-marked form.

ZONOTRICHIA LEUCOPHRYS LEUCOPHRYS (J. R. Forster). White-crowned Sparrow.

Common migrant; not uncommon winter resident.

The first White-crowned Sparrows come down from the north early in October and are present in numbers until the first or second week in November, after which only a few scattered wintering flocks remain. They are again numerous from late March or early April until the first week in May (May 14, 1916, latest). Their haunts are the same as those of the Harris's Sparrow.

ZONOTRICHIA LEUCOPHRYS GAMBELI (Nuttall). Gambel's Sparrow.

Rather rare migrant and winter resident.

A few scattered flocks of this subspecies are to be found on the prairies of western Jackson County during winter, being more numerous in open winters.

To Mr. Dix Teachenor belongs the credit of discovering the fact that these prairie birds are *gambeli* and not *leucophrys* as supposed. Specimens were taken in the region southwest of the Country Club on February 25, 1917.

ZONOTRICHIA ALBICOLLIS (Gmelin). White-throated Sparrow.

Very common migrant.

The White-throated Sparrow arrives from the south early in April (March 28, 1898; March 25, 1905; March 23, 1907, earliest

dates) and is present until the middle of May, being most abundant about the third week in April. It is present again during October and is usually gone before the first of November. The only winter record is January 17, 1904, when a flock of fifty was seen by Smithson in the adjoining county.

This sparrow is usually found with other large Fringillidae and may be looked for in all parts of the county in suitable open districts, along hedges and brushy ravines, weedy fields, roadside tangles and about the edges of timber. It is plentiful in the Swope Park neighborhood and in the Missouri bottoms.

SPIZELLA MONTICOLA MONTICOLA (Gmelin). Tree Sparrow.

Abundant winter resident.

The first Tree Sparrows arrive from their northern breeding grounds from the 13th to 21st of October, but are not numerous until well into November. From then on until early March they are present in great numbers throughout the county. After the first few days in April they are no longer present (April 15, 1906; April 9, 1917, latest).

This species and the Junco are the commonest winter birds and are usually found together. They are abundant in the outskirts of the city during winter.

SPIZELLA MONTICOLA OCHRACEA Brewster. Western Tree Sparrow.

Winter visitant, probably fairly common.

There are nine specimens of the Western Tree Sparrow in the Teachenor series which testify to its regular occurrence in the neighborhood of Lawrence. A large enough series of Tree Sparrow skins taken in Jackson County has not yet been assembled to show in what proportion the two forms occur in the immediate neighborhood of Kansas City.

SPIZELLA PASSERINA PASSERINA (Bechstein). Chipping Sparrow.

Very common summer resident.

The Migrating Chipping Sparrows arrive from March 17th (earliest) to the 30th, usually about the 20th. The local birds take up their breeding stations during the first week in April and announce their presence about the parks and boulevards by

their dry, monotonous, high-pitched song. The four or five eggs are laid in the horsehair nest during the latter part of April.

They leave for the south in October and are seldom seen late in the month (November 5, 1916, only November record).

SPIZELLA PALLIDA (Swainson). Clay-colored Sparrow.

Not uncommon migrant.

This sparrow is present from the middle of April to the end of the second week in May (May 17, 1916, latest) and again during October. It does not seem to migrate in very large flocks and, though easily distinguished in the field, it is not a conspicuous bird and may go unnoticed, unless one is familiar with its hoarse, wheezy song.

It is found on the prairie regions, about open farming country, and in the bottom lands. It has been noted in the Swope Park and Country Club neighborhoods and is a regular visitor to the Atherton and Courtney districts.

SPIZELLA PUSILLA PUSILLA (Wilson). Field Sparrow.

Very common summer resident and occasional winter resident.

The Field Sparrow arrives in the first week of March, though a few impatient males are heard singing sometimes as early as the 15th of February. It becomes common by the third week of March. During the last half of October and November the bulk of the flight passes south. A few are to be seen in December (December 25, 1910; December 17, 1916) and a very small number probably remain all winter. They nest in early May, on the ground or in low bushes.

Field Sparrows inhabit open places near timber, particularly where there is an undergrowth of buckberry (*Symphoricarpus orbiculatus* Moench). They are very common about Swope Park.

SPIZELLA PUSILLA ARENACEA Chadbourne. Western Field Sparrow.

Migrant, probably not rare.

The Field Sparrows of this region present a perplexing problem to the writer. A dozen or more skins that have been examined are certainly not typical *pusilla*, nor do they exhibit all the characters that mark *arenacea*, though they are much closer,

in fact, nearly identical with, the latter. The only eastern specimen available for comparison—a skin from Massachusetts—shows much brighter coloration on the back, no indication of a grayish median stripe on the pileum, and a much shorter tail. Five local specimens taken in the fall (October) are decidedly paler in color and have the characteristic pileum of the western form. The tails and wings also average longer, and, though the ventral characters do not exactly coincide with Ridgway's description, the five specimens are so close to *arenacea* that they may be with little doubt referred to that subspecies.

Whether an intermediate form breeds here (as is suspected) will be known as soon as a series of summer specimens can be studied.

JUNCO AIKENI Ridgway. White-winged Junco.

Very rare winter visitant.

This Junco has been seen a few times during severe winters by Bush in the neighborhood of Courtney. It was also observed by Smithson near Warrensburg on March 21, 1904. It probably occurs here only during occasional and very severe winters. A specimen was taken by Mr. Dix Teachenor near Lawrence on October 24, 1912.

JUNCO HYEMALIS HYEMALIS (Linn.). Slate-colored Junco.

Abundant winter resident.

Early in the second week of October the first Snowbirds are usually seen (October 5, 1901; October 7, 1917, earliest) and a week or ten days later hordes of migrants are present. Great numbers are to be found in all suitable localities over the entire county during winter.

The northward movement begins late in February and by the 10th to 15th of April only stragglers are present (April 23, 1907; April 25, 1915; April 22, 1916, latest dates).

This is our most familiar winter bird and may be found in abundance within the city.

JUNCO HYEMALIS CONNECTENS Coues. Shufeldt's Junco.

Migrant and winter visitant.

A large series of Juncos taken in this district by several collectors and assembled for study has yielded several specimens closely, if not quite, approaching this as well as the following

subspecies. Typical specimens of this race have been taken near Lawrence by Teachenor and others.

JUNCO HYEMALIS MONTANUS Ridgway. Montana Junco.
Migrant and winter visitant.

The remarks on the preceding subspecies are equally applicable to the Montana race. The winter range of this form extends east to the Mississippi River, and, as may be expected, the Montana Junco is occasionally found in Jackson County. At least four specimens are at hand which in the writer's opinion are referable to *montanus*. The comparative abundance of the Juncos will, however, be an open question until more material can be studied.

MELOSPIZA MELODIA MELODIA (Wilson). Song Sparrow.
Very common migrant and fairly common winter resident; very rare summer resident.

The spring movement of Song Sparrows begins early in March and migrants are abundant for the next three weeks. By the last few days of April or the first three or four days of May no more are to be seen save an occasional nesting pair. The first returning migrants are usually seen from the 5th to 10th of October and the bulk of the flight passes during the next three or four weeks.

The wintering birds are most numerous in the thick shelter of the Missouri bottoms but may be found in small flocks on the uplands as well. They are rather common in the Swope Park district and on up the Blue Valley where food and thick shelter are to be had during the most severe winters.

Bush has occasionally found Song Sparrows nesting in the Courtney district.

MELOSPIZA LINCOLNI LINCOLNI (Audubon). Lincoln's Sparrow.
Fairly common migrant and rare winter resident.

The Lincoln's Sparrow arrives from the 13th to the 23rd of April (March 28, 1916, earliest migrant) and is present until between the 5th and 8th of May (May 19, 1916, latest). The first fall migrants are noticed about the middle of October and numbers are present until the second week in November. A few are always seen in December and there are a half dozen January records.

They seem to occur most commonly in the Missouri bottoms and bluff regions, but are found in suitable sparrow territory over the entire county.

The beautiful though rather subdued song of this sparrow is regularly heard in late April and early May, and occasionally in the fall (October 14, 1917).

MELOSPIZA GEORGIANA (Latham). Swamp Sparrow.

Common migrant and not uncommon winter resident.

The first northbound Swamp Sparrows arrive early in March though during mild seasons they may come as early as the middle of February. They are present until late in April and the last are seen during the first week in May (May 9, 1914, May 9, 1915, latest). The autumn migrants are present from the middle of October until the first or second week in November, after which only the scattered winter residents are to be found.

Like the Lincoln's Sparrow this bird seems to like best the bottoms and bluffs along the river, especially in winter, where there is to be found plenty of food and shelter in the grassy sloughs and deep tangles of underbrush. In less numbers they are also found on the prairie regions in winter, about hedges, thickets, wooded ravines, weed patches and brushy creek bottoms.

PASSERELLA ILIACA ILIACA (Merrem). Fox Sparrow.

Very common migrant and fairly common winter resident.

During open and mild winters when the Fox Sparrow is common, it is difficult to say just when the migrants arrive, though they are particularly numerous all during March. The few April records are for stragglers and are all in the first half of the month. The first fall migrants arrive late in September and become common early in October, the bulk passing during the first three weeks. After the first week in November only the wintering birds are left. The Fox Sparrow may be said to be an irregular winter resident, since it is very numerous in all parts of the county during some winters and during others only a few scattered birds are to be found in the thickest cover of the deep sheltered bottom lands.

During the migration periods they are found everywhere in the open country but the largest flocks follow the bluffs and bottoms along the Missouri River.

PIPILO ERYTHROPHTHALMUS ERYTHROPHTHALMUS (Linn.). Towhee.

Common summer resident and abundant migrant; irregular winter resident.

Not many days before or after the 15th of March the returning Towhees announce their presence from every thicket and wooded ravine and hillside. For about three weeks the woods are full of singing migrants. At this time they are to be found even along the streets and boulevards of the city. Nesting begins late in April and early May. The southward movement is noticeable early in October and the birds present in November will remain all winter unless driven further south by unusual cold. These wintering birds are few even in mild winters.

Towhees are common over the entire county in suitable localities and may be found in the cemeteries, parks and suburbs.

PIPILO MACULATUS ARCTICUS (Swainson). Arctic Towhee.

Very rare winter visitant.

Bush states that he has observed the Arctic Towhee at rare intervals near Courtney during severe winters and that specimens have been taken. Bunker gives it as rare in eastern Kansas during winter.

CARDINALIS CARDINALIS CARDINALIS (Linnaeus). Cardinal.

Very common resident.

Some question exists as to the status of our Cardinal. Ridgway states (Bull. 50, U. S. N. M., Birds of North & Middle Amr., part 1, p. 637) that it is very uncertain how far south along the eastern border of the plains this form (*C. c. cardinalis*), or how far north the Texan form (*C. c. canicaudus* —Gray-tailed Cardinal) extends; "possibly even birds from eastern Kansas are referable to the latter." He states further (l. c. p. 636) that specimens from the Mississippi Valley are so completely intermediate between the two forms that they may almost as properly be referred to one as to the other.

There has been available for study a series of ten males and six females from this region and only two male specimens from east of the Allegheny Mountains, but no typical *C. c. canicaudus* has been examined. A carefully drawn up table of measurements shows a very slight increase in the size of the local birds over the eastern specimens. No difference in the distribution

or intensity of the coloration can be detected. A comparison of the females with Ridgway's description of the female *canicaudus* type leads to the conclusion that the local bird is true *C. c. cardinalis,* or is at least much closer to it than to *C. c. canicaudus.* Mr. Dix Teachenor states that his study of the material in the Kansas University Museum leads him to believe that the Gray-tailed Cardinal does not range so far north as Douglas County, Kansas, or Jackson County, Missouri, and that he unhesitatingly referred the specimens in his collection, taken in the Lawrence neighborhood, to the eastern form.

The Cardinal is common throughout the county and is resident during the entire year. It nests freely in the suburbs of the city and is abundant in the parks and cemeteries. Its three or four eggs are laid in May and more than one brood is raised. The nest is a loose, bulky structure placed in low trees, bushes, briar tangles or thick vines.

The Redbird is silent only during the time of moulting, after the last brood of young are out of the nest. Great numbers pass the severe periods of winter in the shelter of Swope Park, in the upper Blue Valley, along the bluffs and in the timbered bottoms.

ZAMELODIA LUDOVICIANA (Linn.). Rose-breasted Grosbeak.

Common migrant; not uncommon summer resident.

The first Rose-breasts arrive between April 19th (earliest) and 29th and are common during early May when the bulk of the migrants are present. After the middle of the month only the breeding birds remain. The autumn migration is noticeable in middle and late September. There are no October records for this vicinity.

Rose-breasted Grosbeaks are to be found in all parts of the county in wooded tracts and even breed sparingly within the city.

GUIRACA CAERULEA CAERULEA (Linn.). Blue Grosbeak.

Recent and very rare summer resident.

Prior to the summer of 1918 there were but three known instances of the occurrence of the Blue Grosbeak in this vicinity, and these records were not entirely satisfactory. On July 13, 1918, a nest containing young was found in a peach orchard on the farm of Mrs. M. J. Morrin, just east of Swope Park.

Both old birds were observed feeding the young, and the male sang almost continuously. Mrs. Morrin states that the birds were present during the summer of 1917. This is the most northern breeding record for Missouri. A pair observed by Smithson near Warrensburg in June, 1904, were possibly nesting.

Like the Bewick's Wren this bird seems to be extending its range in this direction.

PASSERINA CYANEA (Linn.). Indigo Bunting.

Very common summer resident.

The Indigo Bunting arrives regularly during the last three days in April or the first three days in May. It nests in late May and early June and leaves for the south during the early part of October.

It is found in dry, open woodlands, about the edges of thick timber, along brushy ravines, hillsides or roads and in any country overgrown with brush. It is very common in the Swope Park district, on the prairies in favorable localities, in the bottom country and bluff regions and along railroads.

PASSERINA AMOENA (Say). Lazuli Bunting.

Occasional or accidental visitant.

Only wanderers out of their range are likely to be met with in this vicinity. One specimen has been taken here, two have been taken at St. Joseph, Missouri, and one at Leavenworth, Kansas.

SPIZA AMERICANA (Gmelin). Dickcissel.

Very common summer resident.

The Dickcissels arrive during the last half of April and are very common early in May. Nesting begins by the middle of the month and two or three broods are raised. They leave in September, very few remaining into October.

The Dickcissel nests on the ground or in low bushes and is a lover of open fields. It is rarely found in the Missouri bottoms except during migration but is very common on the higher regions of the county. About fifteen pairs nest regularly on the rifle range and adjoining meadow in Swope Park but during some unfortunate years, as in 1917, they are all driven off and the nests destroyed by the early mowing of these tracts.

Family TANGARIDAE. Tanagers.

PIRANGA ERYTHROMELAS Vieillot. Scarlet Tanager.

Common summer resident.

The Scarlet Tanager arrives from April 25th (1895, earliest) to the 30th, sometimes not until the last days of the first week in May. Nesting begins in early June, and after the postnuptial moult, when the young are on the wing, the birds leave for the south. The migrating period occupies nearly all of September. By the first of October all have left.

The Tanagers are woods-loving birds and are always found in the neighborhood of timber.

This species has a general distribution over the county and breeds in the timbered bottoms as well as in the woods of the high country and near the edges of the prairie regions.

It is common in Swope Park and the upper Blue Valley and breeds at several points in the southern suburbs.

PIRANGA RUBRA RUBRA (Linn.). Summer Tanager.

Fairly common summer resident.

This tanager arrives with its congenor in late April or early May and leaves during September. It is perhaps not quite as common as the Scarlet and is never found nesting in the Missouri bottom lands or other low timber. It prefers higher country, particularly dry oak woods, and occasionally builds its nest in orchards or other timber close to habitations.

It is numerous in Swope Park and on the wooded hills and ridges of the upper Blue Valley, as well as in many similar places in the central and southern parts of the county.

Family HIRUNDINIDAE. Swallows.

PROGNE SUBIS SUBIS (Linn.). Purple Martin.

Very common summer resident.

The earliest Martins arrive in mid-March (from the 4th to 26th). These are a few impatients males that are sometimes forced by late storms to rejoin their less venturesome brothers further south. By the last week in March there are always a few present and during the following two weeks they are joined daily by fresh arrivals. It sometimes happens that late sleet storms force the Martins to remain in their roosts for two or three successive days when they starve to death.

Nesting begins early in May and when the young are out the birds begin flocking to common roosts in the bottoms. They leave on the southern journey during early September.

Martins are sociable birds and breed in colonies wherever suitable bird-houses are provided or where they are able to find room in the cornices of old business buildings, as on north Main Street and elsewhere in the city.

To attract a colony of Martins it is necessary to provide a house of several rooms with the entrance holes at the bottom and placed as high from the ground as possible. It is also necessary to have the house out in the open away from trees.

PETROCHELIDON LUNIFRONS LUNIFRONS (Say).

PETROCHELIDON ALBIFRONS ALBIFRONS (Rafinesque). Proposed April, 1917. Cliff Swallow.

Not uncommon migrant; very rare summer resident.

For twenty years prior to 1917 no Cliff Swallows were known to breed in Jackson County. During that summer a colony of about a dozen pairs remained to breed in the neighborhood of Atherton. There are a few colonies in the adjoining counties on the east and north.

During migration they are regularly seen in small numbers hawking for insects over ponds with other swallows.

They arrive in late April and leave in early September.

HIRUNDO ERYTHROGASTRA Boddaert. Barn Swallow.

Abundant migrant and not uncommon summer resident.

The Barn Swallow arrives from the 13th to 20th of April and departs during the last half of September.

It is found in all parts of the county except close to the city. It builds in farm outbuildings, attaching its mud and straw nest to rafters, beams and walls.

Hosts of these and other swallows are to be found in the Missouri bottoms during migration where they find congenial roosting and feeding places. Numbers of swallows are also to be found over the Swope Park lakes during May and September.

IRIDOPROCNE BICOLOR (Vieillot). Tree Swallow.

Very common migrant.

During the second half of April and early May, and in September and October the White-bellied Swallow is abundant.

During this time it is to be found hawking for insects over any body of water with other swallows and flocking to the lowlands to roost.

It breeds not far to the north but has never been found nesting in this county.

RIPARIA RIPARIA (Linn.). Bank Swallow.

Common summer resident.

The Bank Swallow arrives during the last half of April and leaves in the first and second weeks of September. It may be found in migration about any suitable feeding place in the company of other swallows but in the breeding season is found only near the Missouri River. Great numbers breed in colonies in the high sandy banks of the river and in the exposed faces of the deep deposits of loess along the bluffs. Several railroad cuts at the base of the bluffs afford suitable sites for their nesting burrows.

This swallow may be distinguished from the Rough-wing, in whose company it is often found, by the dusky throat band. The Rough-wing has a dusky patch that is not clearly defined by the unmarked throat.

STELGIDOPTERYX SERRIPENNIS (Audubon). Rough-winged Swallow.

Common summer resident.

The Rough-wing arrives sometimes as early as April 4th but more often near the 15th or 20th and is present until late September. It is more widely distributed in this county in summer than the Bank Swallow though it has much the same nesting habits. It breeds in crevices in masonry, particularly in bridges but also in clay banks, but never in large colonies like those of the Bank Swallow, nor in such deep burrows.

It has been seen feeding about the Swope Park lakes during summer and no doubt nests in the park.

Family BOMBYCILLIDAE. Waxwings.

BOMBYCILLA GARRULA (Linn.). Bohemian Waxwing.

Very rare and irregular winter visitant.

Only three specimens of this rare and uncertain bird have ever been taken in this vicinity: February 27, 1911, December

25, 1916, and another, date unknown, taken in Platte County by Jno. Bryant.

The Bohemian Waxwing may occur more frequently than is known and students should closely scrutinize and follow up every winter flock of Cedar Waxwings seen in the hope of finding it. It is easily distinguished by its much larger size and by the presence of white in the wing.

BOMBYCILLA CEDRORUM Vieillot. Cedar Waxwing.

Irregular, sometimes common, migrant and winter resident; doubtful summer resident.

The following dates selected from a mass of notes on this bird will show the puzzle of its local occurrence.

Jan.	17,	1915. Twenty.	Apr.	30,	1896. Flock.
Jan.	26,	1905. Small flock.	May	6,	1894. Flock.
Feb.	4,	1894. Numbers.	May	7,	1911. Twelve.
Feb.	11,	1904. Few.	May	20,	1916. Flock.
Feb.	15,	1917. Eighteen.	May	25,	1894. Small flock.
Feb.	20,	1916. Twelve.	May	30,	1904. Flock.
Feb.	21,	1901. Numbers.	May	30,	1916. Twenty-five.
Mar.	2,	1914. Twenty.	Jun.	2,	1894. Few.
Mar.	5,	1903. Flock.	Jun.	4,	1894. Few.
Mar.	6,	1898. Small flock.	Jun.	5,	1907. Few.
Mar.	12,	1916. Thirty.	Jun.	8,	1897. Few.
Mar.	19,	1915. Forty.	Oct.	8,	1916. Forty.
Mar.	26,	1914. Flock.	Oct.	17,	1915. Flock.
Apr.	4,	1907. Large flock.	Oct.	31,	1904. Seventy.
Apr.	5,	1896. Twenty.	Nov.	5,	1893. Flock.
Apr.	9,	1905. Three.	Nov.	13,	1893. Flock.
Apr.	17,	1905. Flock.	Nov.	30,	1916. Two.
Apr.	28,	1917. Small flock.	Dec.	25,	1916. Eight.

The Cedar Waxwing probably occurs during the three months not given and yet it has never been known to breed in this vicinity.

Flocks are likely to be met with in any part of the county. They are fond of hackberries, persimmons, wild grapes, choke cherries and many other kinds of wild fruit found here in abundance.

They sometimes swoop down into the shade trees along the

boulevards but are most often seen in the Missouri bottoms and bluff regions.

Family LANIIDAE. Shrikes.

LANIUS BOREALIS Vieillot. Northern Shrike.

Rare winter visitant.

The Northern Shrike is distinctly larger than the Migrant Shrike, and may be recognized in the field by its size by a careful observer familiar with the latter species. It may be looked for anywhere in the county during winter. It is never numerous and in some winters is not seen. It is likely to be met with any time between early November and late March or early April.

Three specimens only are known to have been taken in this vicinity, November 24, 1901, January 18, 1909 (Dankers), the third date not being available. Bush gives several dates on which he has observed this bird.

LANIUS LUDOVICIANUS EXCUBITORIDES Swainson. White-rumped Shrike.

Accidental visitant.

Only one specimen of this western shrike has ever been taken in the county (April 25, 1902), and it is considered only accidental. Its range in this latitude extends as far east as central Kansas.

LANIUS LUDOVICIANUS MIGRANS W. Palmer. Migrant Shrike.

Common summer resident; occasional winter resident.

The Migrant Shrike is the breeding form for this district and arrives commonly from the 12th to 20th of March. It departs in late October and early November and a few may remain during mild and open winters. Even in severe winters an occasional bird is seen.

This shrike is fairly common over the whole county but is most numerous on the prairies and open farming country, particularly where the osage orange hedges afford it breeding places. It is seldom seen in the Swope Park neighborhood but is common south of the Country Club district and on the high country south and east of Forest Hill Cemetery and beyond Dodson.

The nesting period is during the last two weeks of April and

later. Four to seven eggs are laid and two broods are often raised.

Family VIREONIDAE. Vireos.

VIREOSYLVA OLIVACEA (Linn.). Red-eyed Vireo.

Common summer resident.

The Red-eyed Vireo arrives regularly during the last four days of April and leaves during the last week of September. It is our commonest vireo and comes freely into the wooded sections of the city to breed. One pair even yet comes to nest in a thicket on the ledge in Penn Valley Park, a few blocks from the Union Station. Red-eyed Vireos are numerous in and about Swope Park, in some of the cemeteries, in the wooded sections bordering the Country Club and other districts within the city and along the bluffs. The nesting season begins about the second week in May.

VIREOSYLVA PHILADELPHICA Cassin. Philadelphia Vireo.

Rather rare migrant.

There are but six known records of the local occurrence of this vireo, all during the month of May. Two specimens have been taken by Tindall on May 10, 1893, and May 8, 1898, respectively.

VIREOSYLVA GILVA GILVA (Vieillot). Warbling Vireo.

Common migrant and not uncommon summer resident.

The Warbling Vireo rarely arrives in numbers before the first week in May though singing males are occasionally heard as early as the middle of April. It leaves for the south during the first two weeks of September.

During migration Warbling Vireos may be found in wooded places in every part of the county but in summer they seem to prefer the bluff regions and neighboring territory. They are heard singing during the nesting season about Independence, Courtney, Atherton and Sibley and in the Missouri and lower Blue Valleys. They have been found nesting in Fairmount Park.

LANIVIREO FLAVIFRONS (Vieillot). Yellow-throated Vireo.

Not uncommon summer resident.

The Yellow-throated Vireo arrives about the middle of April and leaves in late September. This vireo loves damp woods and

prefers thick wooded creek bottoms and ravines near water. It nests regularly in Shilo Hollow at the edge of Swope Park and in the Hazel Dell neighborhood within the Park. It is most numerous during migration in the Missouri Valley and along the bluffs.

LANIVIREO SOLITARIUS SOLITARIUS (Wilson). Blue-headed Vireo.

Not uncommon migrant.

The Solitary Vireo is a comparatively late visitor, arriving during the last few days in April or the first week in May, often remaining till the last of May (May 26, 1893, May 15, 1899, May 18, 1915, and May 28, 1916, latest). It leaves for the south during the last few days of September. It is seen regularly along Brush Creek in the Country Club district, in the Missouri and Blue Valleys, along the bluffs, about Independence and in Swope Park.

VIREO GRISEUS GRISEUS (Boddaert). White-eyed Vireo.

Fairly common summer resident.

The White-eyed Vireo arrives from April 26th to May 4th and leaves during the second and third weeks of September at which time it is usually in full song.

The nesting period begins early in June. It is found in the rich undergrowth of timbered places near streams and near the edges of clearings. It breeds in such places over the entire county but is more numerous in the Missouri bottoms and along the bluff ravines and creeks. Several pairs nest regularly in and about Swope Park.

VIREO BELLI BELLI Audubon. Bell's Vireo.

Fairly common summer resident.

The Bell's Vireo was made known to science by Audubon who met with it for the first time in the bottom lands of the Missouri between Fort Leavenworth and St. Joseph. The first specimen was shot by J. G. Bell, a member of Audubon's party, on May 4, 1843. The Bell's Vireo and the Harris's Sparrow are the two birds which have been discovered in the territory covered in this list.

This vireo arrives during the first days of May, seldom before the third (April 30, 1899, April 27, 1900, earliest), and leaves for the south shortly after the middle of September.

This species is not so closely associated with thick woods as most of the other vireos and may be found on the prairie regions in thickets, hedges, bushes and small clumps of trees or shrubbery. It nests in the outskirts of the city and may be found in the neighborhood of Swope Park as well as other easily accessible places further west and south. It nests early in June.

Family Mniotiltidae. Wood Warblers.

Mniotilta varia (Linn.). Black and White Warbler.

Common migrant and rather rare summer resident.

The Black and White Warbler arrives from the 15th to 20th of April (April 11, 1915, earliest) and is very common in the wooded sections of the county until the middle of May. From then on until the first week in September only the breeding birds are present. During the first two weeks of September the migrants are again numerous.

This distinctively marked warbler breeds in the less frequented sections of Swope Park where it has been observed carrying nesting material and feeding full grown young. Unlike most of the warblers it often feeds near the ground on the trunks of trees and among low bushes and is easy of approach.

During the spring migration, when the birds are mating, they are seen in numbers in wooded territory over the entire county, particularly in Swope Park.

Prothonotaria citrea (Boddaert). Prothonotary Warbler.

Common summer resident.

The Prothonotary Warbler arrives irregularly from the middle to last of April (April 7, earliest) and leaves during the first half of September.

It nests in holes and cavities and prefers to be near water. It breeds along the Blue in the Swope Park district and is common in the Missouri bottom timber near swampy and damp places. Deserted woodpecker holes in standing dead trees or stumps are favorite nesting sites.

Great numbers migrate up and down the Missouri Valley.

Helmitheros vermivorus (Gmelin). Worm-eating Warbler.

Not uncommon summer resident.

The Worm-eating Warbler arrives during the first few days

in May and leaves early in September. It is most numerous during the second week in May when the bulk of the migrants pass. At this time it is evenly distributed over the wooded sections of the entire county. In the breeding season it is found only about rocky ledges bordering thick timber, preferably near creek bottoms or damp ravines. Such conditions are found in and about Swope Park where the dry monotonous song of this warbler is heard regularly during summer. This song is very similar to that of the Chipping Sparrow but is distinguishable from it in being higher pitched and more rapid in execution. The songs, too, are never heard in the same environment.

VERMIVORA PINUS (Linn.). Blue-winged Warbler.

Rather rare summer resident.

The Blue-winged Warbler arrives during the last days of April and during the next ten days northbound migrants are present in numbers in the wooded regions of the county.

Its buzzing notes are heard all summer in the less frequented woods of Swope Park where it seems to be increasing in numbers during recent years. With the exception of some of the wilder bluff regions, the conditions for the successful raising of its young are more favorable in Swope Park than in any other region of the county.

VERMIVORA CHRYSOPTERA (Linn.). Golden-winged Warbler.

Extremely rare migrant.

Though there is but one record of the local occurrence of this warbler (May 9, 1889, Bush) it is not considered as merely accidental. It migrates regularly through the eastern part of the state and occurs sparingly south of this district. It is hoped that students may be able to secure and transmit further data regarding this species.

VERMIVORA RUBRICAPILLA RUBRICAPILLA (Wilson). Nashville Warbler.

Not uncommon migrant.

The Nashville Warbler arrives from April 25th to May 5th and is most numerous during the second week in May. The latest spring record is May 22, 1916, which is an extremely late date. The returning migrants pass through during the last half of September.

This warbler is found in all wooded sections of the county, including the southern and eastern suburbs of the city.

VERMIVORA CELATA CELATA (Say). Orange-crowned Warbler.
Not uncommon migrant.

The Orange-crowned Warbler arrives during the last week of April (April 17, 1916, earliest) and is present until the middle of May (May 20, 1916, latest). Its passage through the county is never marked by any great numbers. The earliest fall arrivals are noted about the middle of September (Sept. 14, 1903, earliest) and individuals are present until the middle of October.

On account of the lack of any bold markings the Orange-crowned Warbler is difficult to distinguish in the field and is often overlooked. It frequents low thick bushes more than other species. The bird may generally be discovered by its song, which is feeble and sounds like an unsuccessful effort to keep on one key. It may be looked for in the timbered bottoms and bluff regions of the Missouri River and in the upper Blue Valley in the Swope Park and Dodson districts, and in thickets even in the residence district in the city.

VERMIVORA PEREGRINA (Wilson). Tennessee Warbler.
Very common migrant.

With the possible exception of the Myrtle, the Tennessee Warbler is our commonest warbler. The birds first arrive during the last few days of April and become most numerous during the first ten days of May. Stragglers are sometimes seen as late as May 25th (1916, three). The southward movement is noticeable in late September and the first half of October.

At the height of migration the nervous staccato song of this species resounds from every tree, even in the outer residence section of the city.

COMPSOTHLYPIS AMERICANA USNEAE Brewster. Northern Parula Warbler.
Very common migrant and not uncommon summer resident.

The Parula Warbler arrives from the 16th to 28th of April and leaves during the last half of September. During the first week or ten days of May the spring migration is at its height and the tall timber of the bottom lands fairly teems with these buzzing and persistent songsters. They are somewhat gaudily

marked birds but are difficult to see as they feed among the dense foliage of the highest tree tops.

They breed in the Missouri and Blue Valleys and may be commonly found in Swope Park during summer.

One form of the song of this species is similar to that of the Cerulean Warbler but may be distinguished by a difference in the opening notes, which are more drawled in the song of the Parula.

DENDROICA TIGRINA (Gmelin). Cape May Warbler.

Very rare migrant.

The only known records of the occurrence of this warbler in this vicinity are May 22, 1909, May 11, 1911, May 11, 1912 and April 26, 1915. The record for May 11, 1912, was made over the state line in Johnson County, Kansas.

DENDROICA AESTIVA AESTIVA (Gmelin). Yellow Warbler.

Very common migrant and common summer resident.

The Yellow Warbler arrives regularly during the last five or six days of April. During early May when the bulk of the migrants are present, they are distributed over the entire county. This species is most numerous in the Missouri bottoms between May 2nd and 7th when it may be said to fairly swarm in the willow thickets. It also prefers to nest in the bottom lands and in the wide valleys leading into these regions. It has never been found in Swope Park in summer but there is one breeding record for the lower Brush Creek region not far to the west.

It is not seen in this county after the first week or ten days in September.

[DENDROICA CAERULESCENS CAERULESCENS (Gmelin). Black-throated Blue Warbler.]

Probable migrant.

This warbler has been reported several times to the east and west of this district but there is no known instance of its occurrence in the immediate vicinity. Students should be on the lookout for this distinctively marked species during migration times.

DENDROICA CORONATA (Linn.). Myrtle Warbler.

Very common migrant and rather rare winter resident.

During favorable winters when there is an abundant supply

of their favorite food, the fruit of the poison ivy, at least a few flocks of Myrtle Warblers are present in the thick timbered sections of the bluff regions and bottom lands. In some winters, as in 1914-15 and 1915-16, these birds are to be found in noticeable numbers during the most severe weather conditions.

The migrants begin arriving from the 16th to 25th of March and by the middle of April are present in large numbers throughout the entire county. Very few are seen after the first week in May though an occasional straggler lingers until rather late in the month (May 20, 1916, latest).

The earliest fall birds reach here from September 27th (1908, earliest) to late in the first week of October, and by the last of the month the migrants are gone and only winter numbers are present.

These warblers may be looked for during migration in any wooded place. They pass through Swope Park in great numbers and are found along the boulevards and about lawn shade trees. They are restless birds but often feed low down in the trees and in bushes and are easy of approach.

Dendroica magnolia (Wilson). Magnolia Warbler.

Regular but rather uncommon migrant.

The Magnolia Warblers pass through at the height of the spring migration between the 11th and 16th of May. No fall records are available but the returning migrants should be looked for during the second and third, and possibly fourth, weeks of September. They may be found in the tall trees along the rivers and creeks, and even in the hawthorn and crab thickets of the outer residence districts.

The greatest number ever noticed in one year was on May 14, 1917, when more than ten birds were seen between Independence and Courtney (Tindall).

Dendroica cerulea (Wilson). Cerulean Warbler.

Common migrant and not uncommon summer resident.

The first Cerulean Warblers are usually heard on May 1st, rarely before (April 29, 1900, earliest), and sometimes not until the last days of the first week of May. They leave early for the south, not being seen usually after late August. As they haunt the tops of the highest trees they are more often heard

than seen, and during their silence after the breeding season are often overlooked.

They are to be looked for in thick bottom timber. Several pairs nest regularly in the damp woods of Shilo Hollow and Hazel Dell, in Swope Park. They also breed in the Missouri Valley.

The song is similar to one form of the Parula Warbler's song but may be distinguished by its opening, which consists of a series of double notes briskly given. The two are often heard together in the woods near the south suspension bridge across the Blue River in Swope Park.

DENDROICA PENSYLVANICA (Linn.). Chestnut-sided Warbler.

Very rare migrant.

There are but eight available records of the occurrence of this warbler in Jackson County. It was observed on April 30th during two years and from the 13th to 20th of May during five others. No autumn records are available.

DENDROICA CASTANEA (Wilson). Bay-breasted Warbler.

Very rare migrant.

This warbler has been reported as rare both to the east and west of this district and there is but a single local record, of ancient origin (Hoy). Students should be on the lookout for further records.

DENDROICA STRIATA (J. R. Forster). Black-poll Warbler.

Common migrant.

The Black-poll brings up the rear of the north-bound warbler army and is commonest during the second and third weeks of May. The advance guard usually arrives between the 2nd and 7th of May though in favorable seasons it may arrive earlier (April 27, 1900, April 28, 1904, April 29, 1915, earliest). The southward flight passes during September.

The Black-poll Warblers may be looked for in all wooded sections of the county and in the park cemeteries.

DENDROICA FUSCA (Muller). Blackburnian Warbler.

Rather rare migrant.

Blackburnian Warblers appear about the end of the first week in May and are rarely seen after the 20th (an exceptionally late date is May 30, 1904). They pass through on the re-

turn flight from the 10th to 25th of September. They are never numerous. They are to be looked for in wooded places beloved of the warblers. Several records have been made in Swope Park.

DENDROICA DOMINICA ALBILORA. Sycamore Warbler.

Not common migrant; probable summer resident.

This region is on the western edge of the range of the Sycamore Warbler, and though it is a regular migrant and very possibly a more or less regular summer resident, it has not been often noted.

This warbler is one of the first to appear in spring, being preceeded only by the Myrtle Warbler. The earliest available record is April 7, 1918 (mouth of Indian Creek).

The Sycamore Warbler is a frequenter of tall trees in bottom land along water courses. It is difficult to see in the tree tops, but is distinctively marked and has a very characteristic song, the manner of delivery of which recalls the Indigo Bunting.

DENDROICA VIRENS (Gmelin). Black-throated Green Warbler.

Not common migrant.

The Black-throated Green Warbler is present during the first three weeks of May and during all of September. It is never present in very great numbers.

It may be looked for in the wilder parts of Swope Park, in the Dodson region and in the timber of the Missouri and Blue Valleys.

DENDROICA VIGORSI (Audubon). Pine Warbler.

Regular but not common fall migrant.

The Pine Warbler is regularly seen here between September 3rd and October 16th, during which time it is often in full song. It is given as a fall migrant only as it has never been observed here in spring. This is perhaps merely an oversight as it migrates north through eastern Kansas and eastern Missouri. Students should be on the lookout for this bird in the spring in the hope of establishing a new record.

Some recent records are: Sept. 3, 9 and 10, 1914 (singing), Sept. 9, 14, and 15, 1915 (singing), Sept. 10, 1916, and Oct. 16, 1916.

DENDROICA PALMARUM PALMARUM (Gmelin). Palm Warbler.

Regular but not numerous migrant.

The Palm Warbler arrives from April 27th to May 7th but is never very numerous. It passes through on the southward flight between the 5th and 11th of October.

Usually single birds are seen, though sometimes they occur in small troops of twos and threes. They may be looked for in the timber of the Missouri and Blue Valleys and in Swope Park.

DENDROICA DISCOLOR (Vieillot). Prairie Warbler.

Occasional.

There is but one known record of the occurrence here of the Prairie Warbler—May 6, 1911, near Dodson.

SEIURUS AUROCAPILLUS (Linn.). Oven-bird.

Common migrant and rather rare summer resident.

The Oven-bird arrives during the last week of April and increases in numbers in the first week of May. At this time it may be looked for in all thickly wooded places over the county, especially in the bluff and bottom regions and in such places as the upper Blue Valley. The migrants are again present during September.

The only places in the county where this warbler is known to breed are a few wild sections of the bluff regions, as near Sibley, and on the dry wooded ridge in Swope Park south of Hazel Dell. In the latter place the songs of the Ovenbird and Kentucky Warbler, which are very similar, may be heard together.

SEIURUS NOVEBORACENSIS NOTABILIS Ridgway. Grinnell's Water-Thrush.

Not rare migrant.

This northwestern form of the Water-Thrush passes through this region regularly during the first half of May (April 29, 1917, earliest; May 15, 1916, latest) and during September.

It is to be looked for either in the same kind of territory as that frequented by the southern species, which is the breeding form for this region, or in swampy places in woods. With the aid of glasses the two forms are readily distinguishable in the field and may be further identified by their noticeably different songs.

The Grinnell's Water-Thrush is a regular migrant through

Swope Park. It has been observed at close range in the small swamp in the woods near the Swope rifle range.

SEIURUS MOTACILLA (Vieillot). Louisiana Water-Thrush.

Common migrant and not uncommon summer resident.

Our earliest arrival date for this warbler is April 1, 1905, though the average is ten days or two weeks later. During the first week in May numbers of migrants are found along the streams, especially along the banks of the Missouri River in the willow thickets and other dense growths standing on high cutting banks. The fall migratory flight passes through in September.

These warblers breed not uncommonly in the ravines and creek bottoms of the bluff regions and in the valleys of the Big and Little Blue. They nest also in favorable places in and about Swope Park.

OPORORNIS FORMOSUS (Wilson). Kentucky Warbler.

Rather common summer resident.

The Kentucky Warbler arrives during the first week of May, though occasionally earlier (April 30, 1899, April 29, 1900, April 29, 1917), and leaves late in September. It nests in the deep woods of the Missouri Valley and in the thick undergrowth along the wooded creek bottoms of the higher regions. It is fairly common as a breeder in certain favorable sections of Swope Park and the upper Blue Valley. Three pairs nested in Shilo Hollow during the summer of 1917 and had not left their breeding stands on September 3rd. Bush states that they nest in the coarse grass and sedge along swamps and sloughs in the Courtney district.

OPORORNIS AGILIS (Wilson). Connecticut Warbler.

Very rare migrant.

Only two local records of this warbler are available. One was seen near Independence on May 12, 1914. On May 15, 1916, one was observed at close range in the Country Club region and was heard to sing repeatedly. It was feeding in a clump of Buckberry bushes under large trees from which it sang as it did also from a small thorn tree and from the ground. The song was loud and clear and Carolina Wren-like and may be transcribed as Wee-chipper, Wee-chipper, Wee-chipper, Chip (Hoffmann).

OPORORNIS PHILADELPHIA (Wilson). Mourning Warbler.

Regular but not numerous migrant.

The ten available records of the local occurrence of this warbler are between May 13th and 23rd. They have been noted in the Missouri bottoms and bluff timber, in Swope Park, and in the Country Club region. Their presence here on the return flight has thus far been overlooked.

GEOTHLYPIS TRICHAS TRICHAS (Linn.). Maryland Yellow-throat.

Very common summer resident.

The Yellow-throats arrive regularly between the 23rd and 29th of April (April 19, 1914, only earlier date). These early arrivals announce their presence first from the bottom lands, but are soon scattered over the uplands as well. From May 5th to 10th the greatest numbers are present in the willow thickets along the Missouri River.

The breeding birds are evenly distributed over the county and may be looked for along all water courses, even ditches, and in any damp woods or low bushy places. They nest within the city in Swope Park, along the Blue and Brush Creek Valleys, in the Country Club and Rockhill regions, in the cemeteries and along Cliff Drive. They nest about the middle of May and lay from four to six eggs.

The fall migration begins during the first days of September and continues through the month, very few birds being seen during the last week.

ICTERIA VIRENS VIRENS (Linn.). Yellow-breasted Chat.

Common summer resident.

Like several of the warblers, the earliest Chats are to be looked for in the thick tangles of the Missouri bottoms where the bulk of the migrants pass. These forerunners appear regularly between the 24th and 29th of April. By the 5th to 10th of May the crest of the migration wave is passing.

This warbler inhabits thickets, briar tangles, bushy ravines, second-growth timber, burnt-over hillsides and all kinds of brushy undergrowths. Three to six eggs are laid late in May.

The Chat is something of a skulker, but is occasionally caught at his clownish antics. A good place to hear the indescribable song of this species is in the neighborhood of the rifle range meadow in Swope Park.

The Chats disappear from their breeding stations early in August (August 4, 1904, family party) and the fall migration is not noticeable, as the birds are then silent and secretive.

WILSONIA CITRINA (Boddaert). Hooded Warbler.

Rare visitant and possible occasional breeder.

The few local records of this warbler are, with one exception, from the timbered regions of the Missouri bottoms and are between the 8th and 25th of May. On May 25, 1916, a pair seen near Independence may have been breeding.

WILSONIA PUSILLA PUSILLA (Wilson). Wilson's Warbler.

Not uncommon migrant.

The Wilson's Warbler is present from May 1st to 20th and again during the first week or ten days of September. It seems to prefer the upland wooded regions, since there are but three records from the bottom lands. It passes through regularly on both spring and autumn migration, but is never present in very great numbers.

WILSONIA PUSILLA PILEOLATA (Pallas). Pileolated Warbler.

Occasional migrant.

Only one Pileolated Warbler has been taken in the county; near Independence (Ridgway, Birds of North and Middle America, U. S. N. M. Bull. No. 50, Vol. 2, p. 712). A specimen was taken by Bunker and Wetmore near Lawrence, Kansas, on October 17, 1908.

WILSONIA CANADENSIS (Linn.). Canada Warbler.

Rare and irregular migrant.

During some years a few of these warblers pass this way and during others none are seen. Their nearest regular migration route, where they pass in great numbers, is the valley of the Mississippi River. The latest record for this species is one bird seen on May 13, 1916.

SETOPHAGA RUTICILLA (Linn.). Redstart.

Very common migrant and fairly common summer resident.

Redstarts arrive from the 25th to 30th of April and leave during September. In early May, when the migrants are most numerous, they are present in all parts of the county in wooded places and may be looked for in all the city parks and along the

boulevards. During the breeding season they resort to damp woods and timbered creek bottoms and are then fairly common in Swope Park, the upper Blue Valley, the Missouri bottoms and bluffs and many other like places. Three to four eggs are laid in early June.

Family Motacillidae. Wagtails.

ANTHUS RUBESCENS (Tunstall). Pipit.

Fairly common migrant.

The fall migration of Pipits is more noticeable than the vernal passage, since the flocks are much larger and remain in one place for a longer period. They arrive from the north in flocks of often several hundreds during early October (Sept. 30, 1897, earliest) and are present in some years till November 22 (1914). The greatest numbers are present from the 13th to 30th of October.

Pipits frequent bottom clearings, grass and alfalfa fields and open spaces at the edges of willow thickets where the ground vegetation is scant. They also feed about the banks of ponds and in barnyards and burnt-over places on the prairie regions. At one farm pond where the surrounding spaces are favorable feeding grounds, a flock of about two hundred Pipits arrived on October 20, 1916, and remained until November 10th.

The spring migration begins about March 29th and is over by May 2nd (1915, latest date).

Pipits may be looked for in the open districts of the Missouri bottoms and in favorable places on the prairie regions. They have been observed in the neighborhood of Swope Park and about Dodson.

ANTHUS SPRAGUEI (Audubon). Sprague's Pipit.

Rare migrant.

Only two known specimens of this form have been taken. The Sprague's Pipit is given by Bunker as a rare migrant in eastern Kansas. It may occur regularly in large flocks of the preceding species.

Family Mimidae. Thrashers, Mockingbirds, etc.

MIMUS POLYGLOTTOS POLYGLOTTOS (Linn.). Mockingbird.

Fairly common summer resident; somewhat rare and irregular winter resident.

As a winter resident the Mockingbird is irregular or has

escaped notice during some winters. It has been observed in December, January or February of 1898, 1904, 1906, 1907, 1910, 1916 and 1917.

It appears at its breeding station very irregularly from March 1st to April 10th and leaves usually in early August, sometimes later.

The Mockingbird prefers the neighborhood of man and since the improving of the Rockhill and Country Club regions and Swope Park it has greatly increased within the city. It nests in these districts as well as in the cemeteries, the Marlborough neighborhood, and about Dodson and Independence. Four eggs are laid in early June. More than one brood is raised, young birds having been found as late as September 4th (1913).

DUMETELLA CAROLINENSIS (Linn.). Catbird.

Very common summer resident.

The first Catbirds are seen between April 25th and May 2nd (April 19, 1903, earliest). Great throngs of migrants are present between the 5th and 9th of May in the willows of the Missouri bottoms. They leave about the middle of September, and from the 17th to 20th of the month the willows again swarm with migrants. Only an occasional straggler is seen after the first day of October.

This familiar bird is a common breeder within the city wherever there is thick shrubbery or bushy cover. Like the Mocker, it takes kindly to the protection of man and, though a somewhat shy bird, it is noticeably on the increase. Four or five eggs are laid during the middle of May and later another nest is built and at least one more brood raised.

TOXOSTOMA RUFUM (Linn.). Brown Thrasher.

Very common summer resident.

The first of the migrating Brown Thrashers arrive from the 1st to the 6th of April, though occasionally single birds are seen much earlier (Feb. 28, 1904; March 26, 1905; March 26, 1914). The local birds arrive on their breeding stands and begin singing from the 10th to 15th of April. They leave during the last half of September and none are seen after the last few days of the month. They breed freely within the city in the same districts and in the same kind of brushy cover as the Catbird. The two species do not nest close together, however, as they are mortal enemies during the breeding season and

have been known to battle to the death over a disputed nesting site.

Four or five eggs are laid in late April and three broods are often raised.

Family Troglodytidae. Wrens.

Thryothorus ludovicianus ludovicianus (Latham). Carolina Wren.

Common resident.

The Carolina Wren is present during the entire year and is one of the few winter songsters. It is to be looked for in any kind of wooded territory and is common in the Swope Park district, in the Blue Valley and Brush Creek woods and in all the wilder sections of the county.

It nests among overhanging roots along creeks and ravines or in holes in the banks. One nest was found by Tindall in a wagon bridge near Independence. Five to seven eggs are laid in early May and more than one brood is raised. One nest was found on August 15, 1901, containing three fresh eggs (Tindall).

Thryomanes bewicki bewicki (Audubon). Bewick's Wren.

Very rare visitant or summer resident.

This wren is slowly extending its range northward and has probably already reached the extreme south and east borders of the county, as it has been regularly seen in the adjoining county (Johnson) since 1907. Since its arrival in the latter district it has established itself as a breeder and has become noticeably less rare. Smithson states that he has seen as many as six in one morning at Warrensburg and has several times seen them carrying nesting material.

The Bewick's Wren is a much more desirable neighbor than the House Wren, as its beautiful song has none of the harsh and penetrating and, to some, disagreeable qualities of that bird. It is also more beautiful, graceful and less quarrelsome than the House Wren.

Troglodytes aedon parkmani Audubon. Western House Wren.

Very common summer resident.

Impatient House Wrens have been seen here as early as March 15th (1903) and several times between the 1st and 10th of April. During some years they arrive between the 15th and

21st of April, the bulk of the migrants passing between the 5th and 8th of May, at which time they swarm in the willows of the Missouri bottoms. They leave during early September and are rarely seen after the middle of the month. Some exceptionally late dates are as follows:—Oct. 6, 1901; Oct. 15, 1911; Oct. 15, 1916, and Nov. 7, 1916.

This wren nests in birdhouses, in crevices about buildings, in the pockets of discarded garments, in tin cans and in other similar situations too numerous to list. It also nests in the deep woods of the bottom lands and other wild places in natural cavities in trees and deserted woodpecker holes. Five to seven eggs are laid in May.

NANNUS HIEMALIS HIEMALIS (Vieillot). Winter Wren.

Irregular but not uncommon winter resident.

During those winters when the Winter Wren is present it may be looked for in timbered creek bottoms, ravines, thick brushy places and weedy roadsides. It is to be found in the thick cover of the Missouri bottoms and bluffs and in Swope Park and the Dodson region. During some winters it is fairly common and in others is either absent or present in very few numbers. Our records covering a period of about twenty years show that it is present from September 30 (1906, earliest) to April 19 (1908, latest), being commonest during the first half of October.

CISTOTHORUS STELLARIS (Naumann). Short-billed Marsh Wren.

Rather uncommon migrant and probable summer resident.

This wren is seen most often in the Missouri bottoms about sloughs and grassy swamps. It has also been noted on the prairie regions and in the upper Blue Valley.

All available local records show its presence here during April and in September and early October. Students should be on the lookout for breeding records, as both Marsh Wrens have been found nesting in the swamps of the up-river counties.

TELMATODYTES PALUSTRIS ILIACUS Ridgway. Prairie Marsh Wren.

Rather uncommon migrant and summer resident.

This wren is present from the middle of April till early in May (in Jackson County) and again during late September and October. It occurs most commonly in the Missouri bot-

toms, but has been seen at Lake City and other marshy places on the uplands.

It breeds in the cat-tail swamps of the river lakes in nearby counties, but the nest has not been taken in Jackson County.

Family CERTHIIDAE. Creepers.

CERTHIA FAMILIARIS AMERICANA Bonaparte. Brown Creeper.

Common winter resident.

Regularly on October 8th, 9th or 10th the first Brown Creepers may be expected from the north, remaining until from the 10th to 20th of April. They are most numerous during the second and third weeks of October and in the first week of April. During migration they are distributed over the entire county wherever there are trees. In winter they seem to prefer the woods bordering the prarie regions, though they are common on the bluffs and in the bottom timber, especially in the large timber of the Indian Creek Valley. During the latter period of their stay they are sometimes heard in full song.

Family SITTIDAE. Nuthatches.

SITTA CAROLINENSIS CAROLINENSIS Latham. White-breasted Nuthatch.

Not uncommon resident.

The White-breasted Nuthatch is present during the entire year in the wooded sections of the county. In winter it is a not infrequent visitor within the city, where it hunts for insect food on the trunks of the shade trees. During the breeding season it retires to the deeper woods to nest in cavities in trees. Six to nine eggs are laid in late April.

Its peculiar grunting notes are familiar sounds in the winter woods.

SITTA CANADENSIS Linn. Red-breasted Nuthatch.

Not uncommon migrant.

This small nuthatch is present in varying numbers from the first few days of October (September 30, 1906, earliest) to about the middle of January (January 18, 1913, latest), and again from the middle of March (March 14, 1914, earliest) to the first week of May (May 5, 1917, latest). It is to be looked for in the same kind of wooded places as the preceding species and,

like it, is sometimes seen along the city streets. It has been noted rather regularly in Swope Park, in the Country Club region, in the cemeteries and about Dodson and Independence.

The Red-breasted Nuthatch has been noticed feeding on the seeds of the large ragweed, *Ambrosia trifida*, which it carries to fence posts and hammers open in the cracks in the timber.

Family Paridae. Titmice.

Baeolophus bicolor (Linn.). Tufted Titmouse.

Very common resident.

The monotonous call of the Tifted Tit is a familar sound in the woods during the entire year except in the breeding season. Owing to their numbers and sprightly behavior and their continual calling and answering, they are one of the most conspicuous birds of the winter woods.

They nest commonly in the outlying districts of the city in bird-boxes, old woodpecker holes and other cavities, and are also found in wooded tracts in all parts of the county. Six to eight eggs are laid late in April and early May.

Penthestes atricapillus atricapillus (Linn.). Chickadee.

Very common resident.

The Chickadee, like its relative, the Tufted Titmouse, is present throughcut the year and is evenly distributed over the entire county. It is probably more numerous than the latter and comes into the city to feed during winter in greater numbers.

It nests in cavities, sometimes excavated by itself at the expense of no little labor, and lays from five to seven, rarely eight, eggs in early April.

Penthestes atricapillus septentrionalis (Harris). Long-tailed Chickadee.

Somewhat rare winter visitant and probably rare resident.

A few counties to the north, as well as twenty or thirty miles to the west, this form is the common Chickadee. The few local records are mostly in winter and indicate a partial migratory movement of these neighboring birds. Bush reports that a few are seen in the bottoms in the Courtney district during the entire year and that he considers the bird a regular breeder. The local records are chiefly from the Missouri bottoms.

Family Sylviidae. Kinglets and Gnatcatchers.

Subfamily Regulinae. Kinglets.

Regulus satrapa satrapa Lichtenstein. Golden-crowned Kinglet.

Common migrant and not uncommon winter resident.

Wintering Golden-crowned Kinglets may be found in the wooded bluff and bottom regions, in the cemeteries, in the timber along the Blue and Brush Creek, in the parks and in wooded places at the edges of the prairie country. They arrive from the north usually between the 5th and 10th of October (Sept. 24, 1904, and Sept. 3, 1906, the latter a very exceptionally early date) and the bulk of the migrants are present during the second and third weeks of the month. The spring movement is noticeable during the first three weeks of April, when great numbers of these tiny birds pass through the city. None have been noted later than April 26th.

Regulus calendula calendula (Linn.).

Corthylio calendula calendula (Linn.). Proposed 1917.

Ruby-crowned Kinglet.

Common migrant.

The latest fall records for the Ruby-crowned Kinglet are December 24 and 25, 1916, when a small troop was seen in the Missouri bottom timber. These birds probably did not remain throughout the later cold periods of the winter, but moved on further south. They arrive in the spring with the Golden crowns, but remain later, stragglers having been noted as late as past the middle of May (May 18, 1905, and May 17, 1916) and fairly regularly during the first week of the month. Fall dates are about the same as for the other kinglet.

They frequent timbered places and are to be looked for in the same localities as the Golden-crowns. In migration they are common in the trees and thickets of the outlying residence districts.

Subfamily Polioptilinae. Gnatcatchers.

Polioptilla caerulea caerulea (Linn.). Blue-gray Gnatcatcher.

Common migrant and not rare summer resident.

The Gnatcatchers arrive from the 11th to 20th of April

(March 30, 1913, exceptionally early) and leaves from the middle to last of August. It nests during the middle of May; four or five eggs are laid. The nest is one of the most wonderful examples of bird workmanship known. It is an exquisitely formed cup, rather deep, composed of down from buds, bits of fine twigs and leafy material woven together with spider webs and thickly covered over with delicate bits of lichens. It is saddled on branches or between the forks of horizontal limbs like the nest of the Hummingbird and is usually from twenty to thirty feet from the ground. Favorite nesting sites are dry ledges or hillsides grown over with oak.

Gnatcatchers may be found in the bluff regions, in Swope Park and vicinity, and around Independence and Dodson.

Family Turdidae. Thrushes, Solitaries, Stonechats, Bluebirds, etc.

Subfamily Turdinae. Thrushes.

Hylocichla mustelina (Gmelin). Wood Thrush.

Very common summer resident.

The Wood Thrush is the favorite songbird of most bird lovers, especially those who have not heard the Hermit Thrush. It arrives from the 23rd to 28th of April and leaves during the second and third weeks of September.

It nests during the middle of May in damp woods and timbered creek bottoms and ravines, and comes into the city freely to breed. Some places in town where it nests regularly are Penn Valley Park, Karnes Boulevard, 36th and Gillham, Armour and Paseo (a most unusual place), 46th and Gillham, Rockhill and Country Club regions, Swope Park and all the cemeteries.

Hylocichla fuscescens salicicola Ridgway. Willow Thrush.

Regular but rather rare migrant.

This subspecific form of the Veery is seen regularly during migration, but is never common. The spring records are between the 4th and 23rd of May; the fall records between September 10th and October 14th. It may be looked for in any wooded section of the county, high or low.

Hylocichla aliciae aliciae (Baird). Gray-cheeked Thrush.

Fairly common migrant.

The Gray-cheeked Thrush is present in all wooded sections

of the county, especially in the bluff and bottom regions, between the 1st and 20th of May and in late September. It is noted regularly in Swope Park and the upper Blue Valley and in the timbered sections of the Country Club district.

This Thrush frequently sings in the period of migration, particularly toward the end of its stay, but in very subdued tones.

HYLOCICHLA USTULATA SWAINSONI (Tschudi). Olive-backed Thrush.

Common migrant.

This species is often in full song during the latter days of its spring passage. It arrives during the first week of May, becoming more numerous from the 10th to 20th. At this time it may be looked for in all wooded regions, especially in the river and creek bottoms. Stragglers have been noted during the last days of May and there is one record of a singing male in Swope Park on June 7, 1916 (Shirling). The species is again present during the last half of September.

HYLOCICHLA GUTTATA PALLASI (Cabanis). Hermit Thrush.

Regular and not uncommon migrant.

The Hermit Thrush is the earliest in spring and latest in fall of all the migrant thrushes. It arrives in late March and is seldom seen after the middle of April. It is present again during the first three weeks of October.

It frequents the same wooded places as the others and may be looked for in Swope Park, the upper Blue Valley, in the bluff and bottom timber, near the Country Club, and many other less accessible places in the county.

We have no record of the singing of this species while migrating through this region.

PLANESTICUS MIGRATORIUS MIGRATORIUS (Linn.). Robin.

Abundant migrant, very common summer resident and rather rare but regular winter resident.

It is safe to say that there is not a day in the year when Robins are entirely absent from Jackson County. During the coldest periods of the most severe winters a few are always to be found in the dense shelter of the bottom timber where there is an abundance of wild fruit for food. In open and mild winters they are to be found even within the city.

The forerunners of the migrating throngs arrive from the

10th to the 20th of February, often much earlier, and by the last of the month or in early March migration is under way in earnest. Countless thousands continue to pass until the middle of April, by which time the local birds have young in the nest. The southward migration occupies October and early November. Small flocks may be seen in late November and early December that may move further south at the approach of zero weather, but always a few hardy birds remain.

The Robin has taken kindly to the advance of civilization and is steadily increasing in numbers despite the persecution of it in some southern states, where it is slaughtered in large numbers for food.

SIALIA SIALIS SIALIS (Linn.). Bluebird.

Very common summer resident; rather rare but regular winter resident.

Bluebirds have been seen in and near the city during the coldest periods of seven of the last thirteen winters. The first spring migrants arrive usually in the second week of February, and by the 20th or 25th are common. The bulk of the migrants pass through during the first two weeks of March. Flocks of southbound migrants have been noted as early as September 18th, but the largest flocks are seen about a month later.

SUMMARY.

DATES ON WHICH THE REGULAR SPRING MIGRANTS MAY BE LOOKED FOR

February 1 to 15

Mallard
Pintail
Canada Goose
Robin
Bluebird

February 15 to 29

Herring Gull
Merganser
Hooded Merganser
Snow Goose
White-fronted Goose
Killdeer
Turkey Vulture
Red-tailed Hawk
Meadowlark
Rusty Blackbird
Bronzed Grackle
Purple Finch

March 1 to 7

Gadwall
Baldpate
Green-winged Teal
Redhead
Canvas-back
Lesser Scaup
Ruddy Duck
Blue Goose
Mourning Dove
Cooper's Hawk
Kingfisher
Cowbird
Leconte's Sparrow
Red-winged Blackbird
Harris's Sparrow
Field Sparrow
Song Sparrow
Swamp Sparrow
Fox Sparrow
Mockingbird

March 8 to 20

Blue-winged Teal
Shoveller
Scaup Duck
Great Blue Heron
Coot
Wilson's Snipe
Greater Yellow-legs
Marsh Hawk
Phoebe
Pine Siskin
Savannah Sparrow
Towhee
Purple Martin
Migrant Shrike
Myrtle Warbler

March 21 to April 1

Pied-billed Grebe
White Pelican
Sandhill Crane
Yellow-bellied Sapsucker
Chipping Sparrow
Pipit
Golden-crowned Kinglet
Hermit Thrush

April 2 to 7

King Rail
Least Sandpiper
Semipalmated Sandpiper
Osprey
Northern Flicker
Vesper Sparrow
Henslow's Sparrow
White-crowned Sparrow
White-throated Sparrow
Rough-winged Swallow
Louisiana Water-Thrush
Brown Thrasher
Ruby-crowned Kinglet

April 8 to 15

Ring-billed Gull
Franklin's Gull
Bittern
Green Heron
Black-crowned Night Heron
Pectoral Sandpiper
Yellow-legs
Broad-winged Hawk
Chimney Swift
Yellow-headed Blackbird
Goldfinch
Lincoln's Sparrow
Barn Swallow
Sycamore Warbler
Western House Wren
Short-billed Marsh Wren
Prairie Marsh Wren
Blue-gray Gnatcatcher

April 16 to 20

Eared Grebe
Virginia Rail
Sora
Florida Gallinule
Baird's Sandpiper

April 16 to 20—Continued

Solitary Sandpiper
Buff-breasted Sandpiper
Spotted Sandpiper
Semipalmated Plover
Whip-poor-will
Lark Sparrow
Clay-colored Sparrow
Tree Swallow
Bank Swallow
Black and White Warbler
Prothonotary Warbler
Northern Parula Warbler

April 21 to 25

Wilson's Phalarope
Kingbird
Crested Flycatcher
Baltimore Oriole
Grasshopper Sparrow
Rose-breasted Grosbeak
Dickcissel
Cliff Swallow
Warbling Vireo
Yellow-throated Vireo
Orange-crowned Warbler
Tennessee Warbler
Oven-bird
Maryland Yellow-throat
Yellow-breasted Chat
Redstart
Wood Thrush

April 26 to 30

Least Tern
Black Tern
Upland Plover
Red-headed Woodpecker
Nighthawk
Ruby-throated Hummingbird
Orchard Oriole
Indigo Bunting
Scarlet Tanager
Summer Tanager

April 26 to 30—Continued

Red-eyed Vireo
Blue-headed Vireo
White-eyed Vireo
Blue-winged Warbler
Nashville Warbler
Yellow Warbler
Palm Warbler
Catbird

May 1 to 10

Forster's Tern
Common Tern
Least Bittern
Yellow-billed Cuckoo
Black-billed Cuckoo
Wood Pewee
Acadian Flycatcher
Traill's Flycatcher
Least Flycatcher
Bobolink
Philadelphia Vireo
Bell's Vireo
Worm-eating Warbler
Cerulean Warbler
Black-poll Warbler
Blackburnian Warbler
Black-throated Green Warbler
Grinnell's Water-Thursh
Kentucky Warbler
Wilson's Warbler
Willow Thrush
Gray-cheeked Thrush
Olive-backed Thrush

May 10 to 15

Olive-sided Flycatcher
Yellow-bellied Flycatcher
Cape May Warbler
Magnolia Warbler
Chestnut-sided Warbler
Mourning Warbler
Hooded Warbler

RESIDENTS

The following species occur in this vicinity throughout the entire year:

Bob-white
Red-tailed Hawk
Sparrow Hawk
Long-eared Owl
Barn Owl
Barred Owl
Screech Owl
Great-Horned Owl
Hairy Woodpecker
Downy Woodpecker
Red-bellied Woodpecker
Northern Flicker
Red-headed Woodpecker
Prairie Horned Lark
Blue Jay
Crow
Red-winged Blackbird
Goldfinch
English Sparrow
Cardinal
Carolina Wren
White-breasted Nuthatch
Tufted Titmouse
Chickadee
Robin
Bluebird

WINTER RESIDENTS

In addition to the above, the following species occur in this vicinity regularly during winter:

Rough-legged Hawk
Short-eared Owl
Thick-billed Red-wing
Northern Red-wing
Purple Finch
Pine Siskin
Lapland Longspur
Harris's Sparrow
Gambell's Sparrow
Tree Sparrow
Slate-colored Junco
Song Sparrow
Lincoln's Sparrow
Swamp Sparrow
Fox Sparrow
Myrtle Warbler
Brown Creeper
Golden-crowned Kinglet

IRREGULAR WINTER RESIDENTS

The following species occur in this vicinity irregularly in winter or during mild and open winters. Very rare species and occasional visitants are not included:

Merganser
Mallard
Green-winged Teal
Canada Goose
Mourning Dove
Marsh Hawk
Cooper's Hawk
Western Red-tail
Kingfisher
Yellow-bellied Sapsucker
Red-shafted Flicker
Cowbird
Meadowlark
Rusty Blackbird
Crossbill
White-crowned Sparrow
Field Sparrow
Towhee
Cedar Waxing
Northern Shrike
Migrant Shrike
Mockingbird
Winter Wren
Long-tailed Chickadee

SUMMER RESIDENTS

The following species nest in this vicinity. A very few species are included in the list on such evidence as birds carrying nesting material and being seen in the neighborhood all summer, and old birds feeding young or carrying food to nestlings. Species represented by only one nesting record are placed in the next list.

Pied-billed Grebe
Black Tern
Hooded Merganser
Blue-winged Teal
Bittern
Least Bittern
Great Blue Heron
Green Heron
King Rail
Virginia Rail
Sora
Florida Gallinule
Coot
Spotted Sandpiper
Killdeer
Bob-white
Mourning Dove
Turkey Vulture
Sharp-shinned Hawk
Cooper's Hawk
Red-tailed Hawk
Red-shouldered Hawk
Broad-winged Hawk
Sparrow Hawk
Barn Owl
Long-eared Owl
Barred Owl
Screech Owl
Great Horned Owl
Yellow-billed Cuckoo
Black-billed Cuckoo
Kingfisher
Hairy Woodpecker
Downy Woodpecker
Red-headed Woodpecker
Red-bellied Woodpecker

SUMMER RESIDENTS—Continued

Northern Flicker
Whip-poor-will
Nighthawk
Chimney Swift
Ruby-throated Hummingbird
Kingbird
Crested Flycatcher
Phoebe
Wood Pewee
Acadian Flycatcher
Prairie Horned Lark
Blue Jay
Crow
Cowbird
Red-winged Blackbird
Bell's Vireo
Meadowlark
Western Meadowlark
Orchard Oriole
Baltimore Oriole
Bronzed Grackle
Goldfinch
English Sparrow
Grasshopper Sparrow
Lark Sparrow
Chipping Sparrow
Field Sparrow
Towhee
Cardinal
Rose-breasted Grosbeak
Indigo Bunting
Dickcissel
Scarlet Tanager
Summer Tanager
Purple Martin
Cliff Swallow
Barn Swallow
Bank Swallow
Rough-winged Swallow
Migrant Shrike
Red-eyed Vireo
Warbling Vireo
Yellow-throated Vireo
White-eyed Vireo
Black and White Warbler
Prothonotary Warbler
Worm-eating Warbler
Blue-winged Warbler
Northern Parula Warbler
Yellow Warbler
Cerulean Warbler
Oven-bird
Louisiana Water-Thursh
Kentucky Warbler
Maryland Yellow-throat
Yellow-breasted Chat
Mockingbird
Catbird
Brown Thrasher
Carolina Wren
Western House Wren
Prairie Marsh Wren
White-breasted Nuthatch
Tufted Titmouse
Chickadee
Blue-gray Gnatcatcher
Wood Thrush
Robin
Bluebird

OCCASIONAL OR VERY RARE BREEDERS

Black-crowned Night Heron
Yellow-crowned Night Heron
Short-eared Owl
Least Flycatcher
Yellow-headed Blackbird
Vesper Sparrow
Savannah Sparrow
Henslow's Sparrow
Song Sparrow
Blue Grosbeak
Hooded Warbler
Short-billed Marsh Wren

FORMER BREEDERS

The following species formerly nested here, but have been driven out by the advance of civilization:

Least Tern
Mallard
Shoveller
Wood Duck (may have returned)
Canada Goose
Egret
Woodcock
Upland Plover
Prairie Chicken
Ruffed Grouse
Wild Turkey
Swallow-tailed Kite
Marsh Hawk
Bald Eagle
Osprey
Carolina Paroquet
Ivory-billed Woodpecker
Pileated Woodpecker
Poor-will
Raven

POSSIBLE BREEDERS

The following species probably breed here, but conclusive evidence to prove this is lacking:

Black Rail
Western Horned Owl
Traill's Flycatcher
Sycamore Warbler
Long-tailed Chickadee

EXTRALIMITAL: NOT INCLUDED

The following species have been recorded from the Lawrence region, but are not included in the list:

Mexican Cormorant
Black-necked Stilt
Lewis's Woodpecker
Say's Phoebe
Pine Grosbeak
Pale Goldfinch
Lark Bunting
Western Robin

MIGRANTS

In addition to the above-listed wintering migrants, both regular and irregular, which do not occur here in summer, the following species are found in this region only during migration. The more rare birds are marked with an asterisk.

Holboell's Grebe*
Eared Grebe
Loon*
Parasitic Jaeger*
Herring Gull
Ring-billed Gull
Laughing Gull*
Franklin's Gull
Bonaparte's Gull*
Caspian Tern*
Forster's Tern
Common Tern
Least Tern
Double-crested Cormorant
White Pelican
Red-breasted Merganser
Red-legged Black Duck
Black Duck
Gadwall
Baldpate
Cinnamon Teal*
Shoveller
Pintail
Wood Duck
Redhead
Canvas-back
Scaup Duck
Lesser Scaup Duck
Ring-necked Duck
Golden-eye
Barrow's Golden-eye*
Buffle-head
Old-squaw*
Scoter*
Surf Scoter*
Ruddy Duck
Snow Goose
Greater Snow Goose*
Blue Goose
White-fronted Goose
Hutchins's Goose
Whistling Swan*
Trumpeter Swan*
White-faced Glossy Ibis*
Whooping Crane*
Little Brown Crane
Sandhill Crane
Yellow Rail
Red Phalarope*
Northern Phalarope*
Wilson's Phalarope
Avocet
Woodcock*
Wilson's Snipe
Long-billed Dowitcher*
Stilt Sandpiper*
Knot*
Pectoral Sandpiper
White-rumped Sandpiper
Baird's Sandpiper
Least Sandpiper
Red-backed Sandpiper*

MIGRANTS—Continued

Semipalmated Sandpiper
Western Sandpiper
Sanderling
Marbled Godwit*
Hudsonian Godwit*
Greater Yellow-legs
Yellow-legs
Solitary Sandpiper
Willet*
Western Willet*
Upland Plover
Buff-breasted Sandpiper
Long-billed Curlew
Eskimo Curlew**
Black-bellied Plover*
Golden Plover
Semipalmated Plover
Piping Plover*
Ruddy Turnstone*
Mississippi Kite*
Swallow-tailed Kite
Goshawk*
Krider's Hawk*
Swainson's Hawk*
Golden Eagle
Bald Eagle
Duck Hawk*
Pigeon Hawk
Osprey
Saw-whet Owl*
Snowy Owl*
Western Nighthawk
Sennett's Nighthawk
Arkansas Kingbird*
Olive-sided Flycatcher
Yellow-bellied Flycatcher
Alder Flycatcher*
Horned Lark
Bobolink
Brewer's Blackbird*
Evening Grosbeak*
White-winged Crossbill*
Redpoll*
Snow Bunting*
Smith's Longspur
Chestnut-collared Longspur
Western Savannah Sparrow
Baird's Sparrow*
Western Grasshopper Sparrow
Leconte's Sparrow
White-throated Sparrow
Clay-colored Sparrow
Western Tree Sparrow
Western Field Sparrow
(may breed)
White-winged Junco*
Shufeldt's Junco
Montana Junco
Arctic Towhee*
Tree Swallow
Bohemian Waxwing*
Philadelphia Vireo
Blue-headed Vireo
Golden-winged Warbler*
Nashville Warbler
Orange-crowned Warbler
Tennessee Warbler
Cape May Warbler*
Magnolia Warbler
Chestnut-sided Warbler*
Bay-breasted Warbler*
Black-poll Warbler
Blackburnian Warbler
Black-throated Green Warbler
Pine Warbler
Palm Warbler
Prairie Warbler*
Grinnell's Water-Thrush
Connecticut Warbler*
Mourning Warbler
Wilson's Warbler
Pileolated Warbler*
Canada Warbler*
Pipit
Sprague's Pipit*
Red-breasted Nuthatch
Ruby-crowned Kinglet
Willow Thrush*
Gray-cheeked Thrush
Olive-backed Thrush
Hermit Thrush

BIBLIOGRAPHY

In compiling this list the author has had access only to his own books, and realizes that there are omissions. It is hoped, however, that all the important references are listed. For the sake of economy of space, titles are not given in the customary full bibliographical form.

Any additions that may be communicated by interested students will be appreciated, as it is desired to ultimately complete the list by including every published record from the Kansas City region.

1814. LEWIS, M. and CLARKE, W.—History of the Expedition under the command of Captains Lewis and Clarke, to the sources of the Missouri, thence across the Rocky Mountains and down the River Columbia to the Pacific Ocean. Performed during the years 1804-5-6. By order of the Government of the United States. In two volumes. Philadelphia. 1814.

This edition has not been handled by the writer. There are many subsequent editions, several of which are undesirable from the standpoint of the naturalist. The most desirable is the Harper Edition, edited with notes by Coues.

A few bird notes were recorded while the expedition was passing through the Kansas City region, and will be found under dates of June, 1804, and September, 1806.

1816. BRACKENRIDGE, H. M.—Journal of a Voyage Up the River Missouri; Performed in Eighteen Hundred and Eleven. By H. M. Brackenridge, Esq. Second Edition. Revised and Enlarged by the Author. Baltimore. 1816.

While this item is of no real value to the working ornithologist, it is cited mainly for its references to Thomas Nuttall. It is of great interest in touching on some particularities of this enthusiastic and absent-minded young naturalist on his first trip through this region. His next visit to the same territory, twenty-four years later, is of more importance to the ornithologist.

1817. BRADBURY, J.—Travels in the Interior of America, in the Years 1809, 1810 and 1811. By John Bradbury. Liverpool, 1817.

This English botanist has recorded some interesting bird notes, and a few that are valuable and important. An authentic account is given of the nesting of the Canada Goose not far below what is now Sibley, Jackson County, Missouri. Notes on the Passenger Pigeon are scattered throughout the narrative.

Thomas Nuttall, who was later to acquire fame in the field of ornithology, and who twenty-four years later, in company with John K. Townsend, discovered the Harris's Sparrow in this region, was a member of Bradbury's party.

1823. SAY, THOMAS.—Account of an Expedition from Pittsburg to the Rocky Mountains, performed in the years 1819, and '20, by order of the Hon. J. C. Calhoun, Secy. of War; under the command of Major Stephen H. Long of the U. S. Top. Engineers. From the notes of Major Long, Mr. T. Say, and other gentlemen of the exploring party. Compiled by Edwin James, Botanist and Geologist of the Expedition. In two volumes. With an Atlas. Philadelphia. 1823.

A valuable reference. No serious student of the ornithology of this region can afford to miss reading this narrative, though the scientific matter is buried in foot-notes. The work is rare.

Thos. Say, with Peale and others of the party, collected material and notes on what is now the site of Kansas City, Missouri, and in the immediate vicinity of this point, on the Kaw River, the scientists had a painful and serious experience with Indians.

1839. TOWNSEND, J. K.—Narrative of a Journey across the Rocky Mountains, to the Columbia River, and a Visit to the Sandwich Islands, Chili, etc. With a Scientific Appendix. By John K. Townsend. Philadelphia. 1839.

Townsend and Nuttall crossed Jackson County, Missouri, on April 28, 1834, over the frontier trail between Independence and Westport. Somewhere between the two points, probably in the Blue Valley, Nuttall took the type specimen of the Harris's Sparrow, which he named the Mourning Finch, *Fringilla querula.* Townsend does not mention the incident in his narrative because of the fact that Nuttall had not yet described the bird.

1839-1841. MAXIMILIAN, PRINZ ZU WIED.—Reise in das Innere Nord-America in den Jahren 1832 bis 1834 von Maximilian Prinz zu Wied. Coblenz. Two volumes. Vol. 1, 1839. Vol. 2, 1841.

This work contains much matter relative to the birds of the Missouri Valley, but it is largely omitted from the only American edition the writer has had access to. See Maximilian, 1904. It is understood that one of the few copies of the original edition in this country is owned in Topeka, Kansas.

1840. NUTTALL, T.—A Manual of the Ornithology of the United States and of Canada. By Thomas Nuttall. Second Edition. Two Volumes. Boston. 1840.

The Harris's Sparrow is here given to science. The type locality is given as "a few miles to the west of Independence in Missouri."

1840-1844. AUDUBON, J. J.—The Birds of America, from drawings made in the United States and their Territories. By John James Audubon. New York and Philadelphia. Seven volumes. 1840-1844. Subsequent editions have eight volumes.

The last volume of this and the subsequent editions contains the birds discovered on the Missouri River trip in 1844. A discovery in this region was the Bell's Vireo, the original specimen of which was taken near St. Joseph, in the Missouri bottoms.

1843. MAXIMILIAN, PRINCE OF WIED.—Travels in the Interior of North America. By Maximilian, Prince of Wied. With numerous engravings on wood, and a large map. Translated from the German by H. Evans Loyd. 81 colored plates, folio. London. 1843.

This rare and desirable English edition has not been examined.

1845. FREMONT, JOHN C.—Report of the Exploring Expedition to the Rocky Mountains in the year 1842 and to Oregon and north California in the years 1843-4. By Brev. Capt. J. C. Fremont, of the topographical engineers, under the orders of Col. J. J. Abert, chief of the topographical bureau. Printed by order of the House of Representatives. Washington. 1845.

This report contains little matter of interest to the bird student.

1848. ABERT, J. W.—Notes on a Military Reconnoissance from Fort Leavenworth, in Missouri, to San Diego, in California. By W. H. Emory. Washington. 1848.

Lieut. Abert's notes are in appendix 6 (pp. 386-405), where twenty-six species are added to the Kansas list. This expedition, like others from Fort Leavenworth bound for the west over the Santa Fe trail, passed through what is now Kansas City, and the old frontier settlement of Westport.

1851. HARRIS, EDWARD.—List of Birds and Mammalia found on the Missouri River from Fort Leavenworth to Fort Union. Fifth Annual Report Smithsonian Institute for 1850, 1851, pp. 136-138.

This list is given as an appendix to a narrative by Thaddeus Culbertson, and is of interest as one of the sources of information relative to the occurrence in this region of species long since extirpated or extinct. The author was the patron and close friend of Audubon, and was with him on the memorable Missouri River trip.

1851. KELLEY, WM.—An Excursion to California over the Prairie, Rocky Mountains and Great Sierra Nevada, with a stroll through the diggings and ranches of that country. By William Kelley, J. P. 2 vols. London. 1851.

The writer of this narrative ascended the Kaw from its mouth, and noticed birds by the way. The bird matter is not of unusual interest or value.

1857. BREWER, THOMAS M.—Smithsonian Contribution to Knowledge. North American Oology; Being an Account of the Habits and Geographical Distribution of the Birds of North America during their Breeding Season; with Figures and descriptions of their eggs. By Thomas M. Brewer, M. D. Part 1. Washington City. Published by the Smithsonian Institution. 1857. New York. D. Appleton & Co.

Two or three references to this region are found in the text of this work, only one part of which was published.

1858. Reports of Explorations and Surveys, to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean. Made under the direction of the Secretary of War, in 1853-6. Vol. IX. Birds. By Spencer F. Baird, Assistant Secretary Smithsonian Institution, with the co-operation of John Cassin and George N. Lawrence. Washington, D. C. 1858.

A rather large number of specimens taken in the Kansas City region were used in the preparation of this monumental work. Some material was collected by unknown soldiers stationed at Fort Leavenworth, and sent in by army officers. Among the scientists who collected in this region are Dr. F. V. Hayden, of Lieut. Warren's party; Dr. Kreuzfeldt, of Captain Gunnison's party; W. S. Wood, of Lieut. Bryan's party; Dr. J. G. Cooper, of W. M. Magraw's party (who secured many specimens in Jackson County), and Dr. Suckley. Specimens taken in this region by the Audubon party in 1844 are also tabulated.

1858. Maximilian Prinz zu Wied.—Verzeichniss der Vogel welche auf einer Reise in Nord-America beobachted wurden.<*Journal fuer Ornithologie*, 1858.

This item has not been seen; quoted from Mr. Widmann's book.

1860. Baird, S. F.—The Birds of North America; the description of species based on the collections in the Museum of the Smithsonian Institution. By Spencer F. Baird, assistant secretary of the Smithsonian Institution, with the co-operation of John Cassin, of the Academy of Natural Sciences of Philadelphia, and George N. Lawrence, of the Lyceum of Natural History of New York. With an Atlas of one hundred plates. Philadelphia: J. B. Lippincott & Co. 1860.

This is a reprint of Volume IX of the Pacific Railroad Surveys Reports, 1858, q. v.

1863. Hayden, F. D.—Report on the Geology and Natural History of the Upper Missouri River based on Explorations in 1855, 56 and 57.<*Trans. Amr. Phil. Soc.*, Vol. 12, 1863.

Dr. Hayden was one of the foremost members of the scientific organization connected with the Pacific Railroad Surveys, and contributed much material from the Kansas City region used by Prof. Baird in his epochal revision of North American birds.

1864. Baird, S. F.—Review of American Birds in the Museum of the Smithsonian Institution. By S. F. Baird. Part 1. North and Middle America. Washington. 1864. Smithsonian Misc. Coll. 181.

1865. Hoy, P. R.—Journal of an Exploration of Western Missouri in 1854, under the Auspices of the Smithsonian Institution.<(*Nineteenth*) *Annual Report Smiths. Inst.* (*for* 1864), 1865, pp. 431-438.

This is the first list of Missouri birds published. Notes and specimens were collected in the Kansas City region. This paper is the sole authority for the occurrence here of the Purple Sandpiper.

1872. Allen, J. A.—Notes of an Ornithological Reconnoissance of Portions of Kansas, Colorado, Wyoming and Utah.<*Bull. Mus. Comp. Zool.*, Vol. III, No. 6, July, 1872, pp. 113-183.

Contains notes of interest made during ten days' collecting at Fort Leavenworth. Three articles in the *American Naturalist* for 1872 contain a summary of this valuable paper.

1872. Snow, F. H.—A Catalogue of the Birds of Kansas contributed to the Kansas Academy of Science by Frank H. Snow, Professor of Natural History and Meteorology, in the University of Kansas, at Lawrence. Second edition, October, 1872. Kansas City, 1872. Pp. 16.

Lists 282 species.

1873. C[oues], E.—Ornithology of the West.<*American Naturalist*, vol. VII, 1873, pp. 221-223.

A review of J. A. Allen's paper listed above (1872).

1873. Snow, F. H.—Catalogue of the Birds of Kansas.<*Trans. Kans. State Board of Agriculture for* 1872, April, 1873, pp. 375-386.

Changes were made in this edition of the Snow list, but the total remains 282 species.

1874. Baird, Brewer, and Ridgway.—A History of North American Birds, by S. F. Baird, T. M. Brewer and R. Ridgway. Land Birds. Vols. I-III. Boston: Little, Brown & Company. 1874.

This standard reference cites a few specimens and records from this region.

1874. Coues, Elliott.—Birds of the Northwest. A Handbook of the Ornithology of the Region drained by the Missouri River and its Tributaries. By Elliott Coues, Captain and Assistant Surgeon, U. S. Army, Dept. of Int., U. S. Geol. Survey. Misc. Pub. No. 3. Washington. 1874.

This book is invaluable to the student of birds of the Missouri Valley.

1875. Snow, F. H.—A Catalogue of the Birds of Kansas contributed to the Kansas Academy of Science, by F. H. Snow, Professor of Natural History and Meteorology, in the University of Kansas, at Lawrence. Third Edition. Pamph. 14 pp., 1875.

These lists of Prof. Snow may be consulted with profit by the student of western Missouri birds. The number of species is here increased to 295.

1878. Coues, Elliott.—Birds of the Colorado Valley. A Repository of Scientific and Popular Information concerning North American Ornithology. By Elliott Coues. Part First. Passeres and Laniidae. Bibliographical Appendix. Washington. 1878.

See Coues, 1874. The appendix is especially valuable.

1879. Scott, W. E. D.—Notes on Birds observed during the Spring Migration in Western Missouri.<*Bull. Nuttall Ornith. Club.* Vol. IV, No. 3, July, 1879. Pp. 139-147.

This list was made in the Warrensburg, Johnson County, Missouri, neighborhood, and contains 148 species.

1882. Abert, Col. James W.—List of Birds observed on a March from Fort Leavenworth, Mo., to Santa Fe, N. M., in 1846 and 1847.<*Journal of the Cincinnati Soc. of Nat. Hist.*, Vol. V, 1882.

See Abert, 1848.

1882. Cooke. W. W.—Bird Migration in the Mississippi Valley.<*Forest and Stream.* Vol. XVIII, 1882.

Not seen.

1883. Cooke, W. W.—Bird Migration in the Mississippi Valley.<*Forest and Stream.* Vol. XIX, 1883, Nos. 15, 16, and 20.

Not seen.

1883-1885.—Cooke, W. W.—Mississippi Valley Migration.<*Ornithologist and Oologist.* Vol. VIII, No. 4 (April, 1883) to Vol. X, No. 12 (December, 1885).

Notes were contributed to this valuable series of articles by G. E. Stillwell, of Kansas City, Missouri. This observer is indicated in the text as No. 33.

1884. Baird, Brewer, and Ridgway.—The Water Birds of North America. Mem. Mus. Comp. Zool. Harvard College, XII and XIII. Issued in continuation of the publications of the Geological Survey of California. Vol. I-II. Boston: Little, Brown & Co. 1884.

See Baird, Brewer, and Ridgway, 1874.

1884. Cooke, W. W.—Distribution and Migration of *Zonotrichia querula.*<*Auk*, Vol. I, No. 3, 1884, pp. 332-337.

First atempt to define the limits of the range of Harris's Sparrow.

1885. Dyche, L. L.—The Yellow Rail (*Porzana noveboracensis*) in Kansas.<*Ornith. and Oologist*, Vol. 10, No. 11, 1885, p. 168.

Reports this bird first for the state from the Lawrence region.

1885. Goss, N. S.—Rare Summer Residents in Kansas.<*Auk*, Vol. II, No. 1, Jan., 1885.

Reports nesting of Coot, Mallard, Black Tern, Acadian Flycatcher, Black and White Warbler, and Blue Grosbeak in the neighborhood of Lawrence.

1885. Goss, N. S.—The Yellow Rail in Kansas.<*Auk*, Vol. II, No. 4, 1885, p. 385.

Same specimen reported from Lawrence by Prof. Dyche.

1886. American Ornithologists' Union.—The Code of Nomenclature and Check-list of North American Birds adopted by the American Ornithologists' Union, being the report of the committee of the union on classification and nomenclature. New York. 1886.

1886. Dyche, L. L.—The Red Crossbill (Loxia curvirostra stricklandi) in Kansas.<*Auk*, Vol. III, 1886, pp. 258-261.

Specimens were taken at Lawrence.

1886. Ganett, Albert.—Letter to editor.<*Hoosier Naturalist*, Vol. 2, No. 5, May, 1886, p. 71.

Reports a flight of Crossbills at Lawrence, Kansas, and mentions their feeding habits during a severe spell of winter.

1886. Lantz, D. E.—Mexican Crossbills in Kansas.<*Ornithologist and Oologist*, Vol. XI, No. 4, April, 1886, p. 59.

Reports this bird from the Lawrence region.

1886. Lemmon, Theo. G.—Food of Crows in Winter.<*Ornithologist and Oologist*, Vol. XI, No. 4, April, 1886, p. 59.

An observation from Westport, now included in Kansas City, Missouri.

1886. Lemmon, Theo. G.—Note on Kingbird feeding on potato beetle. <*Ornith. and Oologist*, Vol. XI, No. 5, May, 1886.

1886. Lemmon, Theo. G.—A Plea for our Birds.<*The Kansas City Live Stock Record and Farmer*, December 16, 1886.

Not seen.

1887. Lemmon, Theo. G.—Birds and their Relation to Agriculture. <*Ornith. and Ool.*, Vol. 12, No. 11, November, 1887, p. 180.

Mr. Lemmon was a resident of Westport, Jackson County, Missouri, and was an early investigator in the field of economic ornithology.

1887. Ridgway, Robert.—A Manual of North American Birds, by Robert Ridgway. Illustrated by 464 outline drawings of generic characters. Philadelphia: J. B. Lippincott Company. 1887.

A second edition of this important work was issued in 1896.

1888. BENNETT, A. L.—Surf Scoter in Kansas.<*Auk*. Vol. V, 1888, p. 203.

Note from Lawrence.

1888. COOKE, W. W.—Report on Bird Migration in the Mississippi Valley in the Years 1884 and 1885. By W. W. Cooke. Bull. No. 2, U. S. Dept. of Agri., Div. Econ. Ornith. Washington. 1888.

Notes from this region were contributed by Prof. Snow, of Lawrence, and G. E. Stillwell, of Kansas City.

1888. LIGHTON, LOUIS R.—Original Bird Notes.<*West American Scientist*, Vol. 4, No. 33, January, 1888, p. 15.

Gives dates of arrival of seven common species at Lawrence, Kansas.

1888. SNOW, F. H.—Aechinophorus occidentalis in Kansas.<*Auk*, Vol. V, 1888, pp. 201-202.

Reports Western Grebe taken on Kaw River at Lawrence.

1889. BARROWS, WALTER B.—The English Sparrow (Passer domesticus) in North America, especially in its Relation to Agriculture. Prepared under the direction of Dr. C. Hart Merriam, Ornithologist. By Walter B. Barrows, Assistant Ornithologist. Bull. I, Div. Economin Ornith. and Mammalogy, Dept. of Agri. Washington. 1889.

A small amount of material from this region was used in this bulletin.

1890. DWIGHT, JONATHAN, JR.—The Horned Larks of North America. <*Auk*, Vol. VII, 1890, pp. 138-158.

A few specimens from this region were handled in the preparation of this paper.

1890. W. H. P.—The Lark Sparrow.<*The Literary Companion* (Kansas City, Kansas, paper) Vol. II, N. S., No. 2, February, 1890, p. 2.

1891. Goss, N. S.—History of the Birds of Kansas. By N. S. Goss. Topeka, Kansas. 1891.

Contains much of value to students of the birds of this region.

1891. KELLOG, VERNON L.—Some Rarae Aves among Kansas Ducks. <*The Kansas City Scientist*, Vol. 5, No. 8, August, 1891, pp. 125-126.

Reports the capture of rare species in the Lawrence neighborhood.

1891. TROUSLOT, R. B.—A Handsome Present.<*The Kansas City Scientist*, Vol. 5, May, 1891, p. 77.

This is an editorial reference to a nest and set of six eggs of the Migrant Shrike.

1892. BENDIRE, CHAS.—Life Histories of North American Birds, with special reference to their breeding habits and eggs, with twelve lithographic plates. By Charles Bendire, Captain U. S. Army (Retired), Honorary Curator of the Department of Oology, U. S. National Museum, Member of A. O. U. Smithsonian Institution. United States National Museum. Special Bulletin No. 1. Washington. 1892.

Contains references to this and surrounding territory. Vide Bendire, 1895.

1892. SNOW, F. H.—The Pacific Eider in Kansas.<*Auk*, Vol. IX, 1892, p. 198.

This extralimital species was taken on the Kaw River at Lawrence.

1893. COUES, ELLIOTT.—History of the Expedition under the Command of Lewis and Clark to the source of the Missouri River, thence across the Rocky Mountains and down the River Columbia to the Pacific Ocean, performed during the years 1804-05-6, by order of the Government of the United States. In four volumes. New York. Francis P. Harper. 1893.

Even this late edition is difficult to find. Dr. Coues' notes make this a very desirable edition for the ornithologist. See the *editio princeps*, 1814.

1893. FISHER, A. K.—The Hawks and Owls of the United States in their relation to Agriculture. Prepared under the direction of Dr. C. Hart Marriam, Ornithologist, by A. K. Fisher, M. D., Assistant Ornithologist. Washington. 1893.

This model economic report tabulates a few specimens from Jackson County, Missouri, and surrounding territory.

1893. JORDAN, DAVID STARR.—A Manual of the Vertebrate Animals of the Northern United States, including the district north and east of the Ozark Mountains, south of the Laurentian Hills, north of the southern boundary of Virginia, and east of the Missouri River. By David Starr Jordan. Seventh Edition. Chicago. A. C. McClurg & Company. 1894.

1894. COALE, HENRY K.—Ornithological Notes on a Flying Trip through Kansas, New Mexico, Arizona, and Texas.<*Auk*, Vol. XI, No. 3, 1894, pp. 215-222.

A short paragraph is devoted to a few common species in the immediate neighborhood of Leavenworth, Kansas.

1895. American Ornithologists' Union Check-list of North American Birds, prepared by a committee of the American Ornithologists' Union. Second and revised edition. New York. 1895.

1895. Barrows, Walter B., and Schwarz, E. A.—The Common Crow of the United States. Bull. No. 6, Dept. Agri. Div. Ornith. and Mammalogy. Washington. 1895.

The only local reference is to Douglas County, Kansas, Crow roosts.

1895. Bendire, C.—Life Histories of North American Birds, from the Parrots to the Grackles, with special reference to their breeding habits and eggs, by Charles Bendire, Captain and Brevet Major U. S. Army (Retired), Honorary Curator of the Department of Oology of the United States National Museum, Member of the A. O. U.; with seven lithographic plates. Washington. 1895.

See Bendire, 1892.

1895. Bryant, John A.—Clark's Nutcracker in Eastern [Western] Missouri.<*Auk*, Vol. XII, No. 1, 1895, p. 82.

Records an extralimital species from Kansas City.

1895. Bryant, Jno. A.—Clark's Nutcracker.<*Auk*, 1895, No. 2, 1895, pp. 181-182.

Further notes relative to the occurrence of this bird in this and surrounding territory.

1895. Jones, Lynds.—Record of the work of the Wilson Ornithological Chapter of the Agassiz Association for 1893 and 1894, on the Mnioltiltidae.<*Wilson Bulletin* Nos. 4 and 5, 1895.

Local data is contributed to this report by John A. Bryant, of Kansas City.

1896. Harris, J. H. Jr.—The Florida Gallinule.<*Nidologist*, Vol. III, No. 9, May, 1896, p. 95.

Amateur notes.

1896. Harris, J. H. Jr.—Some Observations on the Spotted Sandpiper. <*Osprey*, Vol. 1, No. 1, pp. 7-8.

Amateur notes.

1896. Wilson, Sidney S.—Harris's Sparrow in Spring Dress in Autumn.<*Auk*, Vol. XIII, No. 2, 1896.

A note from St. Joseph, Missouri.

1896. Wilson, Sidney S.—Field Notes.<*Wilson Bulletin*, No. 8, May 30, 1896.

Mr. Wilson was a St. Joseph, Missouri, observer.

1897. JOHNSON, WALTER ADAMS.—War on the Red-headed Woodpecker. <*Osprey*, Vol. I, No. 11, 1897, p. 147.

Editorial comment on article in the *Kansas City Star*.

1897. WILSON, SIDNEY S.—Letter to editor.<*Nidologist*, Vol. IV, No. 7, March, 1897, p. 81.

An observation from St. Joseph, Missouri, on the manner of the Chimney Swift securing twigs for its nest.

1897. WILSON, SIDNEY, S.—Chimney Swifts Breaking off Twigs with their Feet.<*Osprey*, Vol. I, No. 9, May, 1897, p. 122.

1897. WILSON, SIDNEY S.—Notes from Missouri.<*Wilson Bulletin*, No. 13, 1897, p. 18.

Notes from Buchanan County.

1898. DAVIE, OLIVER.—Nests and Eggs of North American Birds. By Oliver Davie, Author of American Methods in the Art of Taxidermy. Fifth Edition. Revised, Augmented and Illustrated. Columbus. 1898.

1898. WILSON, SIDNEY S.—General Notes.<*Wilson Bulletin*, No. 18, Jan., 1898, pp. 9-10.

1898. WILSON, SIDNEY S.—General Notes.<*Wilson Bulletin*, No. 22, Sept., 1898, p. 69.

1899. LANTZ, D. E.—A Review of Kansas Ornithology.<*Trans. Kans. Acad. Science* (*for* 1896-1897), Vol. XVI, July, 1899, pp. 224-276.

Contains a bibliography (pp. 224-244) and an annotated list of 351 species (pp. 244-276). This is a carefully prepared and valuable paper, but unfortunately seems to be little known among students of western Missouri birds, and the Public Library of Kansas City does not own a copy. The volume of *Transactions* containing this study may be had from the Secretary of the Academy at Lawrence.

1899. WILSON, SIDNEY S.—General Notes.<*Wilson Bulletin*, No. 27, July, 1899, p. 62.

1900. AUDUBON, M. R.—Audubon and his Journals, with Zoological and other notes by Elliott Coues. By Maria R. Audubon. New York. 1900. Two volumes.

In that portion of these historical journals dealing with the Missouri River trip, is to be found a list of birds of the greatest interest and importance to local students. An account is also given of the discovery of Bell's Vireo near St. Joseph, and the supposed discovery of Harris's Sparrow in the same neighborhood.

1900. JONES, LYNDS, and DAWSON, W. L.—A Summer Reconnoissance in the West.<*Wilson Bulletin*, No. 33, October, 1900, pp. 10-11.

Contains a horizon made in the Kansas City region.

1901. RIDGWAY, ROBERT.—Bulletin of the United States National Museum No. 50. The Birds of North and Middle America; A Descriptive Catalogue of the Higher Groups, Genera, Species, and Subspecies of Birds known to occur in North America, from the Arctic Lands to the Isthmus of Panama, the West Indies and other Islands of the Caribbean Sea, and the Galapagos Archipelago. By Robert Ridgway, Curator, Division of Birds. Part I. Family Fringillidae—The Finches. Washington: Government Printing Office. 1901.

Seven volumes of this monumental work, the standard of reference, have appeared to 1918. The early volumes are out of print and in constant demand. Students located in western Missouri will find these indispensable volumes only in a few private libraries.

1901. SNOW, F. H.—A Catalogue of the Birds of Kansas (fifth edition) with Notes upon Preceding Catalogues and Lists. By Francis H. Snow, Ph. D., LL.D., of the University of Kansas.<*Trans. Kans. Acad. Science*, Vol. XVIII. 1901.

This is Prof. Snow's last list and contains 342 specimens. Reprinted May, 1903.

1902. RIDGWAY, ROBERT.—Birds of North and Middle America. Part II. Family Tanagridae—The Tanagers. Family Icteridae—The Troupials. Family Coerebidae—The Honey Creepers. Family Mniotiltidae—The Wood Warblers. Washington. 1902.

See Ridgway, 1901.

1903. COOKE, WELLS W.—Some New Facts about the Migration of Birds. Reprint from Yearbook of Dept. of Agri. for 1902. Washington. 1903.

Contains valuable matter relative to this region.

1903. COUES, ELLIOTT.—Key to North American Birds. Containing a concise account of every species of living and fossil bird at present known from the continent north of the Mexican and United States boundary, inclusive of Greenland and Lower California, with which are incorporated General Ornithology: an outline of the structure and classification of birds; and Field Ornithology, a manual of collecting, preparing, and preserving birds. The Fifth Edition (entirely revised) exhibiting the nomenclature of the American Ornithologists' Union, and including descriptions of additional species. In two volumes. Vol. I (II). By Elliott Coues, A. M., M. D., Ph. D., etc., etc. Boston. Dana Estes and Company. 1903.

1904. BRUNER, WALCOTT, and SWENK.—A Preliminary Review of the Birds of Nebraska with Synopses. By Lawrence Bruner, Robert H. Wolcott, and Myron H. Swenk. Omaha, Nebraska. N. D.

A useful paper on the avifauna of adjacent territory on the northwest.

1904. COOKE, WELLS W.—Distribution and Migration of North American Warblers. By Wells W. Cooke, Assistant, Biological Survey. U. S. Dept. of Agri. Div. of Biological Survey—Bulletin No. 18. Washington. 1904.

Invaluable to the local student.

1904. MAXIMILIAN, PRINCE OF WIED.—Travels in the Interior of North America in the Years 1832 to 1834. Vol. 22 of Early Western Travels, Edited by Reuben Gold Thwaites. Cleveland, Ohio. The Arthur H. Clark Company. 1904.

See Maximilian, 1839-1841.

1904. RIDGWAY, ROBERT.—The Birds of North and Middle America. Part III. Washington. 1904.

See Ridgway, 1901.

1904. SNOW, F. H.—Two Additions to the Bird Fauna of Kansas.< *Auk*, Vol. XXI, 1904, p. 284.

Reports the Parasitic Jaeger and White-winged Crossbill from Lawrence.

1906. COOKE, WELLS W.—Distribution and Migration of North Ameri can Ducks, Geese and Swans. By Wells W. Cooke, Assistant, Biological Survey—Bulletin No. 26. Washington. 1906.

Contains much valuable data from the Mississippi and Missouri Valleys.

1906. SNOW, FRANCIS H.—Two Birds New to the Avifauna of Kansas. <*Auk*, Vol. XXIII, 1906, p. 106.

Red Phalarope taken four miles from Lawrence. Total species and subspecies for state is now 349.

1906. WETMORE, ALEX.—Christmas Bird Census at Lawrence, Kansas. <*Bird Lore*, Vol. 13, No. 1, 1906, p. 22.

1907. ANDERSON, R. M.—The Birds of Iowa. *Proc. Davenport Acad. Science.* Vol. XI. Pp. 125-417. Davenport, Iowa. March, 1907.

Useful reference treating of the birds of adjoining territory on the north.

1907. CHAPMAN, FRANK M.—The Warblers of North America. By Frank M. Chapman with the Co-operation of Other Ornithologists. New York. D. Appleton & Co. 1907.

1907. RIDGWAY, ROBERT.—The Birds of North and Middle America. By Robert Ridgway. Part IV. Washington. 1907.

See Ridgway, 1901.

1907. WIDMANN, OTTO.—A Preliminary Catalogue of the Birds of Missouri. By Otto Widmann. Transactions of the St. Louis Academy of Science. Vol. XVII, No. 1, November 16, 1907. Pp. 1-288.

Missouri ornithologists are very fortunate in having access to Mr. Widmann's vast fund of knowledge of the birds of this region. This report is one of the best state lists extant. It may be procured *from* the Secretary *of* the Academy at St. Louis.

1908. AMERICAN ORNITHOLOGISTS' UNION.—The Code of Nomenclature adopted by the American Ornithologists' Union. Revised Edition. New York. July, 1908.

1908. BAILEY, FLORENCE MERRIAM.—Handbook of Birds of the Western United States, including the Great Plains, Pacific Slope, and Lower Rio Grande Valley. By Florence Merriam Bailey. Third edition. Revised. Boston and New York. Houghton Mifflin Company. N. D. (1908.)

1908. SMITHSON, A. F.—Christmas Census for Kansas City, Missouri. <*Bird Lore*, Vol. 14, No. 1, 1908, p. 34.

1908. WALMSLEY, H. R.—Christmas Census for Kansas City, Missouri. <*Bird Lore*, Vol. 14, No. 1, 1908, p. 34.

1909. WALMSLEY, H. R.—Christmas Census for Kansas City, Missouri. <*Bird Lore*, Vol. 16, No. 1, 1909, p. 35.

1909. WETMORE, ALEX.—Fall Notes from Eastern Kansas.<*Condor*, Vol. XI, No. 5, Sept., 1909.

A valuable paper based on two collecting trips in the Lawrence region.

1909. WETMORE, ALEX.—Two Records from Eastern Kansas.<*Condor*, Vol. XI, No. 6, Nov., 1909.

Notice of specimens of Lewis's Woodpecker and the Western Robin taken in the Lawrence neighborhood.

1909. WORCESTER, URI B.—The Towhee in Kansas.<*Oologist*, Vol. XXVI, No. 12, 1909, pp. 226-227.

Amateur notes.

1910. AMERICAN ORNITHOLOGISTS' UNION.—Check-list of North American Birds. Prepared by a Committee of the American Ornithologists' Union. New York. 1910.

1910. Cooke, Wells W.—The Type Locality of *Vireo belli.*<*Auk*, Vol. XXVII, No. 3, July, 1910.

Establishes the type locality at St. Joseph, Missouri.

1910. Cooke, Wells W.—The Migratory Movements of Birds in Relation to the Weather. Reprint from Yearbook of Department of Agriculture for 1910.

1910. Walmsley, H. R.—Christmas Census for Kansas City, Missouri. <*Bird Lore*, Vol. 16, No. 1, 1910.

1911. Cooke, Wells W.—Distribution of the American Egrets. U. S. Dept. Agri., Bureau Biol. Surv.—Circ. No. 84, Sept. 13, 1911.

Contains notes from the Lawrence region.

1911. Evans, Logan.—*Colymbus holboelli* in Kansas.<*Auk*, Vol. XXVIII, 1911, p. 107.

Reports a specimen of this grebe taken on the Kaw River near Lawrence.

1911. Howell, Arthur H.—Birds of Arkansas. By Arthur H. Howell. Bull. Biol. Surv. No. 38. October 12, 1911. Washington, D. C.

Useful reference for students of western Missouri birds.

1911. Ridgway, Robert.—The Birds of North and Middle America. By Robert Ridgway. Part V. 1911.

See Ridgway, 1901.

1911. Shirling, A. E.—Christmas Census for Kansas City, Mo.<*Bird Lore*, Vol. 17, No. 1, 1911, p. 40.

1912. Bolt, Benj. F.—Capture of a Golden Eagle at Kansas City, Mo. <*Auk*, Vol. XXIX, No. 1, 1912, p. 102.

Reports a late capture of this bird near the city.

1912. Chapman, Frank M.—Handbook of Birds of Eastern North America, with Introductory Chapters on the study of Birds in Nature. By Frank M. Chapman, Curator of Ornithology in the American Museum of Natural History, etc., etc. Revised edition. New York and London. D. Appleton and Company. 1912.

1912. Chapman and Reed.—Color Key to North American Birds, with Bibliographical Appendix. By Frank M. Chapman, with upwards of 800 Drawings, by Chester A. Reed. Revised Edition. New York. D. Appleton & Co. 1912.

Contains a valuable faunal bibliography, referring to this and surrounding territory.

1913. Bunker, C. D.—The Birds of Kansas.<*The Kansas University Science Bulletin*, Vol. VII, No. 5, June, 1913, pp. 137-158.

There are 379 species and subspecies here listed, annotated, for the most part, as to relative abundance in eastern, central, and western Kansas. A valuable paper.

1913. Cooke, Wells W.—Distribution and Migration of North American Herons and their Allies. By Wells W. Cooke, Assistant, Biological Survey. U. S. Dept. Agri., Biol. Surv.-Bull. No. 45. Washington. 1913.

Contains data from this region.

1913. Smithson, A. F.—Some Birds from Southwestern Missouri.<*Auk*, Vol. XXX, No. 3, July, 1913, p. 437.

Notes on Bewick's Wren, Evening Grosbeak, and others from Warrensburg, Missouri.

1913. Walmsley, H. R., and Mrs. Walmsley.—Christmas Census for Kansas City, Mo.<*Bird Lore*, Vol. 18, No. 1, 1913, p. 35.

1913. Wetmore, Alex.—Notes on Certain Kansas Birds.<*Condor*. Vol. XV, No. 3, May, 1913, pp. 120-121.

Report on avian conditions in the Lawrence region during the severe winter of 1911-1912.

1914. Cooke, Wells W.—Distribution of North American Rails and their Allies. Bull. Dept. Agri. No. 128. September 25, 1914.

Contains data from this and surrounding territory.

1914. Ridgway, Robert.—The Birds of North and Middlle America. By Robert Ridgway. Part VI. 1914.

See Ridgway, 1901.

1914. Wetmore, Alex.—A New Bird for the Kansas List.<*Condor*, Vol. XVI, No. 2, March, 1914, p. 92.

Reports *Planesticus migratorius achrusterus* from Lawrence, Kansas.

1915. Cooke, Wells W.—Preliminary Census of Birds of the United States. Bull. Dept. Agri. No. 187. Washington. February 11, 1915.

Contains estimates from a few observers in this region.

1915. Cooke, Wells W.—Bird Migration. U. S. Dept. Agri. Bull. No. 185. Washington. April 17, 1915.

1915. Cooke, Wells W.—Distribution of North American Gulls and their Allies. U. S. Dept. Agri. Bull. No. 292. Professional Paper. Washington, D. C. October 25, 1915.

1915. DONAHUE, RALPH.—Queer Nesting Places and Early Arrival of Slate-colored Junco.<*Oologist*, Vol. XXXII, No. 11, Nov., 1915, p. 188.

1915. WRIGHT, ALBERT HAZEN.—Early Records of the Wild Turkey, V. <*Auk*, Vol. XXXII, 1915, pp. 354-358.

A list of early publications containing references to the occurrence of the Wild Turkey in this region is cited.

1916. Anonymous [OTTO BOHL].—Bird Life of the North Side.< *The North Side Booster*, Vol. 1, No. 26, Dec. 27, 1916.

Notes in a Kansas City Trade Journal by an old-time observer on former conditions in the old part of the city.

1916. COOKE, WELLS W.—Second Annual Report of Bird Counts in the United States, with discussion of Results. Dept. Agri. Bull. No. 396. Washington. October 23, 1916.

See "Preliminary Census," Cooke, 1915.

1916. DONAHUE, RALPH.—Easy Food for the Red-head.<*Oologist*, Vol. XXXIII, No. 11, Oct., 1916, p. 178.

1916. HOFFMANN, RALPH.—The Pomarine Jaeger and the Purple Gallinule in Western Missouri.<*Auk*, Vol. XXXIII, No. 2, April, 1916, p. 196.

Reports two birds new to the Kansas City region, one of which is new to the state.

1916. KALMBACH, E. R.—Winter Crow Roosts. By E. R. Kalmbach, Assistant Biologist, Biological Survey. Reprint from Yearbook of Dept. Agri. for 1915. Washington. 1916.

1916. K. C. BIRD CLUB MEMBERS.—Christmas Census for Kansas City, Missouri.<*Bird Lore*, Vol. XIX, No. 1, 1917, pp. 37-38.

1916. RIDGWAY, ROBERT.—The Birds of North and Middle America. By Robert Ridgway. Part VII.

See Ridgway, 1901.

1917. DONAHUE, RALPH.—The Phoebe.<*Oologist*, Vol. XXXIV, No. 2, Jan., 1917, p. 20.

1917. DONAHUE, RALPH.—The Black-capped Chickadee.<*Oologist*, Vol. XXXIV, No. 8, Oct., 1917, p. 152.

1917. DONAHUE, RALPH.—Bird Accidents.<*Oologist*, Vol. XXXIV, No. 8, 1917, p. 153.

1917. BUNKER, C. D.—American Goshawks in Kansas.<*Auk*, Vol. XXXIV, Jan., 1917, pp. 87-88.

Notes an unusual invasion of these birds in the severe winter of 1916-1917.

1917. HOFFMANN, RALPH.—Christmas Bird Census for Kansas City, Missouri.<*Bird Lore*, Vol. 19, No. 1, 1917, pp. 35-35.

Forty-two species and 3,740 individuals.

1917. SHIRLING, A. E.—Christmas Bird Census for Pleasant Hill, Missouri.<*Bird Lore*, Vol. 19, No. 1, 1917, p. 35.

1917. HYDE, A. SIDNEY.—Some Rare Birds of Eastern Kansas.<*Oologist*, Vol. XXXIV, No. 9, Sept., 1917.

1917. SHIRLING, A. E.—The Season. (Letter from Kansas City, Mo.) <*Bird Lore*, Vol. 19, 1917, p. 154.

1917. SHIRLING, A. E.—Summer Birds of Swope Park.<*Bird Lore*, Vol. 19, 1917, p. 273.

This is a brief notice of an elaborate ecological study prepared by Mr. Shirling, but which has not yet been published. It will be a valuable contribution to the subject and should be referred to by local students as well as others.

1918. HARRIS, HARRY.—Notes from the Kansas City Region. The Season.<*Bird Lore*, Vol. 20, 1918, pp. 165-166.

1918. HARRIS, HARRY.—Notes from the Kansas City region. The Season.<*Bird Lore*, Vol. 20, 1918, pp. 431-432.

1919. HARRIS, HARRY.—Historical Notes on the Harris's Sparrow (*Zonotrichia querula*)<*Auk*, Vol. XXXVI, No. 2, 1919, pp. —.

INDEX.

A

Acadian Flycatcher, 280, 336, 338
Acanthis linaria linaria, 291
Acippiter cooperi, 261
velox, 260
Actitis macularius, 254
Aechmophorus occidentalis, 223
Aegialitis meloda, 256
semipalmata, 256
Agelaius phoeniceus arctolegus, 287
fortis, 286
phoeniceus, 285
predatorius, 285
Aix sponsa, 235
Alaudidae, 282
Alcedinidae, 271
Alcyones, 271
Alder Flycatcher, 281, 340
Aluco pratincola, 266
Aluconidae, 266
Ammodramus bairdi, 295
savannarum australis, 295
bimaculatus, 296
Anas platyrhynchos, 231
rubripes rubripes, 232
tristis, 232
Anatidae, 230
Anatinae, 231
Anhinga anhinga, 228
Anhingidae, 228
Anser albifrons gambeli, 239
Anseres, 230
Anserinae, 238
Anthus rubescens, 325
spraguei, 325
Antrostomus vociferus, 275
carolinensis, 275
Aphrizidae, 256
Aquila chrysaetos, 264
Archibuteo ferrugineus, 264
lagopus sancti-johannis, 263
Archilochus colubris,277
Arctic Towhee, 304, 340
Ardea herodias herodias, 242
Ardeidae, 241
Ardeinae, 242
Arenaria interpres morinella, 256
Arenariinae, 256
Arkansas Kingbird, 278, 340
Arquatella maritima maritima, 250
Asio flammeus, 267
wilsonianus, 267
Astragalinus tristis tristis, 292
Astur atricapillus atricapillus, 261
Avocet, 248, 339

B

Baeolophus bicolor, 330
Baird's Sandpiper, 250, 335, 339
Baird's Sparrow, 295, 340
Bald Eagle, 264, 338, 340
Baldpate, 233, 335, 339
Baltimore Oriole, 289, 336, 338
Bank Swallow, 309, 336, 338
Barn Owl, 266, 336, 337
Barn Swallow, 308, 335, 338
Barred Owl, 268, 336, 337
Barrow's Golden-eye, 237, 339
Bartramia longicauda, 253
Bay-breasted Warbler, 319. 340
Bell's Vireo, 313, 336, 338
Belted Kingfisher, 271
Bewick's Wren, 327
Bibliography, 341
Bittern, 241, 335, 337
Least, 242, 336, 337

Blackbird, Brewer's, 290, 340
Red-winged, 285. 335, 336, 338
Rusty, 289, 335, 337
Yellow-headed, 284, 335, 338
Black-bellied Plover, 255, 340
Black-billed Cuckoo, 271, 336, 337
Blackburnian Warbler, 319, 336, 340
Black-crowned Night Heron, 243, 336, 338
Black Duck, 232, 339
Red-legged, 232, 339
Black-poll Warbler, 319, 326, 340
Black Rail, 246, 339
Black Tern, 228, 336, 337
Black-throated Blue Warbler, 317
Black-throated Green Warbler, 320, 336, 340
Black and White Warbler, 314, 336, 388
Bluebird, 334, 335, 336, 338
Blue Goose, 239, 335, 339
Blue-gray Gnatcatcher, 331, 335, 338
Blue Grosbeak, 305, 338
Blue-headed Vireo, 313, 336, 340
Blue Jay, 283, 336, 338
Blue-winged Teal, 233, 335, 337
Blue-winged Warbler, 315, 336, 338
Bobolink, 284, 336, 340
Bob-white, 256, 336, 337
Bohemian Waxwing, 309, 340
Bombycilla cedrorum, 310
garrula, 309
pallidiceps, 309
Bonaparte's Gull, 226, 339
Bonasa umbellus umbellus, 257
Botaurinae, 241
Botaurus lentiginosus, 241
Branta canadensis canadensis, 240
hutchinsi, 240
Brewer's Blackbird, 290, 340
Broad-winged Hawk, 262, 335, 337
Bronzed Grackle, 290, 335, 338
Brown Creeper, 329, 337
Brown Thrasher, 326, 335, 338
Bubo virginianus pallescens, 269
virginianus, 269
Buff-breasted Sandpiper, 254, 336, 340
Buffle-head, 237, 339
Bunting Indigo, 306, 336, 338
Lazuli, 306
Bunting, Snow, 293, 340
Burrowing Owl, 269
Buteo borealis borealis, 261
calurus, 262
harlani, 262
krideri, 262
lineatus lineatus, 262
platypterus, 263
swainsoni, 263
Buteonidae, 259
Butorides virescens virescens, 243

C

Calcarius lapponicus lapponicus, 293
ornatus, 294
pictus, 293
Calidris leucophea, 252
Campephilus principalis, 272
Canada Goose, 240, 335, 337, 338
Canada Warbler, 324, 340
Canutus canutus rufus, 249
Canvas-back, 235, 335, 339
Cape May Warbler, 317, 336, 340
Caprimulgi, 275
Caprimulgidae, 275
Cardinal, 304, 336, 338
Cardinalis cardinalis cardinalis, 304
Carolina Paroquet, 270, 338
Carolina Wren, 327, 336, 338
Carpodacus purpureus purpureus, 291
Caspian Tern, 227, 339
Catbird, 326, 336, 338
Cathartes aura septentrionalis, 259
Cathartidae, 259
Catoptrophorus semipalmatus inornatus, 253
semipalmatus, 253
Cedar Waxwing, 310, 337
Centurus carolinus, 274
Cepphi, 224
Cerchneis sparvaria sparvaria, 265
Certhia familiaris americana, 329
Certhiidae, 329
Cerulean Warbler, 318, 336, 338
Ceryle alcyon, 271
Chaetura pelagica, 277
Chaeturinae, 277

Charadriidae, 255
Charadrius dominicus dominicus, 255
Charitonetta albeola, 237
Chat, Yellow-breasted, 323, 336
Chaulelasmus streperus, 232
Chen caerulescens, 239
hyperboreus hyperboreus, 238
nivalis, 239
Chestnut-collared Longspur, 294, 340
Chestnut-sided Warbler, 319, 336, 340
Chickadee, 330, 336, 338
Long-tailed, 330, 337, 339
Chicken, Prairie, 257, 338
Chimney Swift, 277, 335, 338
Chipping Sparrow, 299, 335. 338
Chondestes grammacus grammacus, 297
Chordeiles virginianus henryi, 276
sennetti, 277
virginianus, 276
Chuck-will's-widow, 275
Cinnamon Teal, 234, 339
Circus hudsonicus, 260
Cistothorus stellaris, 328
Clamatores, 278
Clangula, clangula americana, 236
islandica, 236
Clarke's Nutcracker, 283
Clay-colored Sparrow, 300, 336, 340
Cliff Swallow, 308, 336, 338
Coccyges, 270
Coccyzinae, 270
Coccyzus americanus americanus, 270
erythrophthalmus, 271
Colaptes auratus luteus, 274
cafer collaris, 274
Colinus virginianus virginianus, 256
Columbae, 258
Columbidae, 258
Colymbi, 223
Colymbidae, 223
Colymbus holboelli, 223
nigricollis californicus, 223
Common Tern, 227, 336, 339
Compsothlypis americana usneae, 316
Connecticut Warbler, 322, 340
Conuropsis carolinensis, 270
ludoviciana, 270
Cooper's Hawk, 261, 335, 337
Coot, 247, 335, 337
Cormorant, Double-crested, 229, 339
Corthylo calendula calendula, 331
Corvidae, 282
Corvinae, 283
Corvus brachyrhynchos brachyrhynchos, 283
corax sinuatus, 283
Coturnicops noveboracensis, 246
Cowbird, 284, 335, 337, 338
Crane, Little Brown, 244, 339
Sandhill, 244, 335, 339
Whooping, 244, 339
Creciscus jamaicensis, 246
Creeper, Brown, 329, 337
Crested Flycatcher, 278, 336, 338
Crossbill, 291, 337, 340
White-winged, 291
Crow, 283, 336, 338
Cryptoglaux acadia acadia, 268
Cuculi, 270
Cuculidae, 270
Cuckoo, Black-billed, 271, 336, 337
Yellow-billed, 270, 336, 337
Curlew, Eskimo, 255, 340
Long-billed, 254, 340
Cyanocitta cristata cristata, 283
Cygninae, 241
Cypseli, 277

D

Dafila acuta, 234
tzitzimoa, 234
Dendroica aestiva aestiva, 371
caerulescens, 317
castanea, 319
cerulea, 318
coronata, 317
discolor, 321
dominica albilora, 320
fusca, 319
magnolia, 318
pensylvanica, 319
palmarum palmarum, 321
striata, 319
tigrina, 317
vigorsi, 320
virens, 320
Dickcissel, 306, 336, 338
Dolichonyx oryzivorus, 284

Double-crested Cormorant, 229, 339
Dove, Mourning, 258, 335, 337
Western Mourning, 259
Dowitcher, 249
Long-billed, 249, 339
Downy Woodpecker, 272, 336, 337
Dryobates pubescens medianus, 272
villosus, 272
Duck, Black, 232, 339
Harlequin, 237
Lesser Scaup, 236, 335, 339
Red-legged Black, 232, 339
Ring-necked, 236, 339
Ruddy, 238, 335, 339
Scaup, 235, 335, 339
Wood, 235, 338, 339
Duck Hawk, 265, 340
Dumetella carolinensis, 326

E

Eagle, Bald, 264, 338, 340
Golden, 264, 340
Eared Grebe, 223, 335, 339
Ectopistes migratorius, 258
Egret, 242, 338
Snowy, 243
Egretta candidissima candidissima, 243
Elanoides forficatus, 259
Empidonax flaviventris, 280
minimus, 281
trailli alnorum, 281
trailli, 281
virescens, 280
English Sparrow, 292, 336, 338
Ereunetes mauri, 251
pusillus, 251
Erismatura jamaicensis, 238
Eskimo Curlew, 255, 340
Euphagus carolinus, 289
cyanocephalus, 290
Evening Grosbeak, 290, 340

F.

Falco columbarius columbarius, 265
richardsoni, 265
mexicanus, 265
peregrinus anatum, 265
sparverius sparverius, 265
Falcon, Prairie, 265
Falcones, 259
Falconidae, 265
Falconinae, 265
Ferruginous Rough-leg, 264
Field Sparrow, 300, 335, 337, 338
Finch, Purple, 291, 335, 337
Flicker, Northern, 274, 335, 336, 338
Red-shafted, 274, 337
Florida caerulea, 243
Florida Gallinule, 246, 335, 337
Flycatcher, Acadian, 280, 336, 338
Alder, 281, 340
Crested, 278, 336, 338
Least, 281, 336, 338
Olive-sided, 280, 336, 340
Traill's, 281, 336, 339
Yellow-bellied, 280, 336, 340
Forster's Tern, 227, 336, 339
Fox Sparrow, 303, 335, 337
Franklin's Gull, 226, 335, 339
Fringillidae, 290
Fulica americana, 247
Fulicinae, 247
Fuligulinae, 235

G

Gadwell, 232, 335, 339
Gallinae, 256
Gallinago delicata, 248
Gallinula chloropus cachinnanus, 246
galeata, 246
Gallinule, Florida, 246, 335, 337
Purple, 246
Gallinulinae, 246
Gambel's Sparrow, 298, 337
Garrulinae, 282
Gavia immer, 224
Gaviidae, 224
Geothlypis trichas trichas, 323
Gnatcatcher, Blue gray, 331, 335, 338
Godwit, Hudsonian, 252, 340
Marbled, 252, 340
Golden-crowned Kinglet, 331, 335, 337
Golden Eagle, 264, 340
Golden-eye, 236, 339
Barrow's, 237, 339

Golden Plover, 255, 340
Golden-winged Warbler, 315, 340
Goldfinch, 292, 335, 336, 338
Goose, Blue, 239, 335, 339
Canada, 240, 337, 338
Greater Snow, 239, 339
Hutchins's, 240, 339
Snow, 238, 335, 339
White-fronted, 239, 339
Goshawk, 261, 340
Crackle, Bronzed, 290, 335, 338
Grasshopper Sparrow, 295, 336, 338
Gray-cheeked Thrush, 332, 336, 340
Great Blue Heron, 242, 335, 337
Great Horned Owl, 269, 336, 337
Greater Snow Goose, 239, 339
Greater Yellow-legs, 252, 335, 340
Green Heron, 243, 335, 337
Green-winged Teal, 233, 335, 337
Grebe, Eared, 223, 335, 339
Holboell's, 223, 339
Pied-billed, 223, 335, 337
Western, 223
Grinnell's Water-Thrush, 321, 336, 340
Grosbeak, Blue, 305, 338
Evening, 290, 340
Rose-breasted, 305, 336, 338
Grouse, Ruffed, 257, 338
Grues, 244
Gruidae, 244
Grus, americana, 244
canadensis, 244
mexicana, 244
Guiraca caerulea caerulea, 305
Gull, Bonaparte's, 226, 339
Franklin's, 226, 335, 339
Herring, 225, 339
Laughing, 226, 339
Ring-billed, 225, 335, 339

H

Hairy Woodpecker, 272, 336, 337
Haliaeetus leucocephalus leucocephalus, 364
Harlan's Hawk, 262
Harlequin Duck, 237
Harris's Sparrow, 297, 335, 337
Hawk, Broad-winged, 263, 335
Cooper's, 261, 335, 337
Duck, 265, 340
Harlan's, 262
Krider's, 262, 340
Marsh, 260, 335, 337, 338
Pigeon, 265, 340
Red-shouldered, 262, 337
Red-tailed, 261, 335, 336, 337
Richardson's Pigeon, 265
Rough-legged, 263, 337
Ferruginous Rough-leg, 264
Sharp-shinned, 260, 337
Sparrow, 265, 336, 337
Swainson's, 263, 340
Western Red-tail, 262, 337
Helmitheros vermivorus, 314
Helodromas solitarius solitarius, 253
Henslow's Sparrow, 296, 335, 338
Herelda hyemalis, 237
Hermit Thrush, 333, 335, 340
Herodias egretta, 242
Herodii, 241
Herodiones, 241
Heron, Black-crowned Night, 243, 335, 338
Great Blue, 242, 335, 337
Green, 243, 335, 337
Little Blue, 243
Yellow-crowned Night, 243, 338
Herring Gull, 225, 335
Hesperiphona vespertina vespertina, 290
Hirundinidae, 307
Hirundo erythrogastra, 308
Histrionicus histrionicus, 237
Holboell's Grebe, 223, 339
Hooded Merganser, 230, 335, 337
Hooded Warbler, 324, 336, 338
Horned Lark, 282, 340
Hoyt's Horned Lark, 282
Hudsonian Godwit, 252, 340
Hummingbird, Ruby-throated, 277, 336, 337
Hutchins's Goose, 240, 339
Hydrochelidon nigra surinamensis, 228
Hydroprogne caspia imperator, 227
Hylocichla aliciae aliciae, 332
fuscesens salicicola, 332
guttata pallasi, 333
mustelina, 332
ustulata swainsoni, 333

I

Ibides, 241
Ibididae, 241
Ibis, White-faced Glossy, 241, 339
Icnornis martinicus, 246
Icteria virens virens, 323
Icteridae, 284
Icterus galbula, 289
Icterus spurius, 289
Ictinia mississippiensis, 260
Indigo Bunting, 306, 336, 338
Iridoprocne bicolor, 308
Ivory-billed Woodpecker, 272, 338
Ixobrychus exilis, 242

J

Jaeger, Long-tailed, 225
Parasitic. 224, 339
Pomarine, 224
Jay, Blue, 283, 336, 338
Junco aikeni, 301
hyemalis connectens, 301
hyemalis, 301
montanus, 302
Junco, Montana, 302, 340
Shufeldt's, 301, 340
Slate-colored, 301, 337
White-winged, 301, 340

K

Kentucky Warbler, 322, 336, 338
Killdeer, 255, 335, 337
Kingbird, 278, 336, 338
Arkansas, 278, 340
Kingfisher, Belted, 271, 335, 337
Kinglet, Golden-crowned, 331, 335, 337
Ruby-crowned, 331, 335, 340
King Rail, 245, 335, 337
Kite, Swallow-tailed, 259, 338, 340
Mississippi, 260, 340
Kittiwake, 225
Knot, 249, 339
Krider's Hawk, 262, 340

L

Laniidae, 311
Lanius borealis, 311
ludovicianus excubitorides, 311
migrans, 311
Lanivireo flavifrons, 312
solitarius solitarius, 313
Lapland Longspur, 293, 337
Laridae, 225
Larinae, 225
Lark, Horned, 282, 340
Hoyt's Horned, 282
Prairie Horned, 282, 336, 338
Lark Sparrow, 297, 336, 338
Larus argentatus, 225
delawarensis, 225
franklini, 226
philadelphia, 226
atricilla, 226
Laughing Gull, 226, 339
Lazuli Bunting, 306
Least Bittern, 242, 336, 337
Least Flycatcher, 281, 336, 338
Least Sandpiper, 251, 335, 339
Least Tern, 227, 336, 338, 339
Leconte's Sparrow, 296, 335, 340
Lesser Scaup Duck, 236, 335, 339
Limicolae, 247
Limosa fedoa, 252
haemastica, 252
Lincoln's Sparrow, 302, 335, 337
Little Blue Heron, 243
Little Brown Crane, 244, 339
Lobipes lobatus, 247
Long-billed Dowitcher, 249, 339
Long-billed Curlew, 254, 340
Long-eared Owl, 267, 336, 337
Longipennes, 224
Longspur, Chestnut-collared, 294, 340
Lapland, 293, 337
McCown's, 294
Smith's, 293, 340
Long-tailed Chickadee, 330, 337, 339
Long-tailed Jaeger, 225
Loon, 224, 339
Lophodytes cucullatus, 230
Louisiana Water-Thrush, 322, 335, 338
Loxia curvirostra minor, 291
leucoptera, 291

M

Macrochires, 275
Macrorhamphus griseus griseus, 249
griseus scolopaceus, 249

Magnolia Warbler, 318, 336, 340
Magpie, 282
Mallard, 231, 335, 337, 338
Marbled Godwit, 252, 340
Mareca americana, 233
Maryland Yellow-throat, 323, 336, 338
Marila affinis, 236
americana, 235
collaris, 236
marila, 235
valisineria, 235
Marsh Hawk, 260, 335, 337, 338
Martin, Purple, 307, 335, 338
McCown's Longspur, 294
Meadowlark, 288, 335, 337, 338
Western, 288, 338
Melanerpes erythrocephalus, 273
Melanitta deglandi, 238
perspicillata, 238
Meleagridae, 258
Meleagris gallopavo silvestris, 258
Melospiza georgiana, 303
lincolni lincolni, 302
melodia melodia, 302
Merganser, 230, 335, 337
Hooded, 230, 335, 337
Red-breasted, 230, 339
Merginae, 230
Mergus americanus, 230
serrator, 230
Micropalama himantopus, 249
Micropodidae, 277
Migrant Shrike, 311, 335, 337, 338
Mimidae, 325
Mimus polyglottos polyglottos, 325
Mississippi Kite, 260, 340
Mniotilta varia, 314
Mniotiltidae, 314
Mockingbird, 325, 335, 337, 338
Molothrus ater ater, 284
Montana Junco, 302, 340
Motacillidae, 325
Mountain Plover, 256
Mourning Dove, 258, 335, 337
Western, 259
Mourning Warbler, 323, 336, 340
Myiarchus crinitus, 278
Myiochanes virens, 280
Myrtle Warbler, 317, 335, 337

N

Nannus hiemalis hiemalis, 328
Nashville Warbler, 315, 336, 340
Nettion carolinense, 233
Nighthawk, 276, 336, 338
Sennet's, 277, 340
Western, 276, 340
Northern Flicker, 274, 335, 336, 338
Northern Parula Warbler, 316, 336, 338
Northern Phalarope, 247, 339
Northern Red-wing, 287, 337
Northern Shrike, 311, 337
Nucifraga columbiana, 283
Numenius americanus, 254
borealis, 255
Nutcracker, Clarke's, 283
Nuthatch, Red-breasted, 329, 340
White-breasted, 329, 336, 338
Nuttallornis borealis, 280
Nyctanassa violacea, 243
Nyctea nyctea, 269
Nycticorax nycticorax naevius, 243

O

Odontophoridae, 256
Oidemia americana, 237
fusca, 238
perspicillata, 238
Old-squaw, 237, 339
Olive-backed Thrush, 333, 336, 340
Olive-sided Flycatcher, 280, 336, 340
Olor buccinator, 241
columbianus, 241
Oporornis agilis, 322
formosus, 322
philadelphia, 323
Orange-crowned Warbler, 316, 336, 340
Oriole, Baltimore, 289, 336, 338
Orchard, 289, 336, 338
Orchard Oriole, 289, 336, 338
Oscines, 282
Osprey, 266, 335, 338, 340

Otocoris alpestris alpestris, 282
hoyti, 282
praticola, 282
Otus asio asio, 268
naevius, 268
Owl, Barn, 266, 336, 337
Barred, 268, 336, 337
Burrowing, 269
Great Horned, 269, 336, 337
Long-eared, 267, 336, 337
Saw-whet, 268, 340
Screech, 268, 336, 337
Short-eared, 267, 337, 338
Snowy, 269, 340
Western Horned, 269, 339
Ovenbird, 321, 336, 338
Oxyechus vociferus, 255

P

Palm Warbler, 321, 336, 340
Paludicolae, 244
Pandion haliaetos carolinensis, 266
Pandionidae, 266
Parasitic Jaeger, 224, 339
Paridae, 330
Paroquet, Carolina, 270, 338
Parula, Warbler, Northern, 316, 336
Passenger Pigeon, 258
Passer domesticus, 292
hostilis, 292
Passerculus sandwichensis alaudinus, 295
savanna, 294
Passerella iliaca iliaca, 303
Passers, 278
Passerherbulus henslowi henslowi, 296
lecontei, 296
Passerina amoena, 306
cyanea, 306
Pectoral Sandpiper, 250, 335, 339
Pelecanidae, 229
Pelecanus erythrorhynchos, 229
Pelican, White, 229, 335, 339
Pelidna alpina sakhalina, 251
Penthestes atricapillus atricapillus, 330
septentrionalis, 330
Petrochelidon albifrons albifrons, 308
lunifrons lunifrons, 308
Pewee, Wood, 280, 336, 338
Phalacrocoracidae, 229
Phalacrocorax auritus auritus, 229
Phalaenoptilus nuttalli nuttalli, 276
Phalarope, Northern, 247, 339
Red, 247, 339
Wilson's, 248, 336, 339
Phalaropodidae, 247
Phalaropus fulicarius, 247
Phasiani, 256
Philadelphia Vireo, 312, 336, 340
Philohela minor, 248
Phloeotomus pileatus abieticola, 273
Phoebe, 279, 335, 338
Pica pica hudsonia, 282
Pici, 272
Picidae, 272
Pied-billed Grebe, 223, 335, 337
Pigeon Hawk, 265, 340
Pigeon, Passenger, 258
Pileated Woodpecker, 273, 338
Pileolated Warbler, 324, 340
Pine Siskin, 292, 335, 337
Pine Warbler, 320, 340
Pintail, 234, 335, 339
Pipilo erythrophthalmus erythrophthalmus, 304
maculatus arcticus, 304
Piping Plover, 256, 340
Pipit, 325, 335, 340
Sprague's, 325, 340
Piranga erythromelas, 307
Piranga rubra rubra, 307
Pisobia bairdi, 250
fuscicollis, 250
maculata, 250
minutilla, 251
Planesticus migratorius migratorius, 333
Plectrophenax nivalis nivalis, 293
Plegadis guarauna, 241
Plover, Black-bellied, 255, 340
Golden, 255, 340
Mountain, 256
Piping, 256, 340
Semipalmated, 256, 336, 340
Upland, 253, 336, 338, 340
Podasocys montanus, 256
Podilymbus podiceps, 223

Polioptilinae, 331
Polioptilla caerulea caerulea, 331
Pomarine Jaeger, 224
Poocetes gramineus gramineus, 294
Poor-will, 276, 338
Porzana carolina, 245
Prairie Chicken, 257, 338
Prairie Falcon, 265
Prairie Horned Lark, 282, 336, 338
Prairie Marsh Wren, 328, 335, 338
Prairie Warbler, 321, 340
Progne subis subis, 307
Prothonotaria citrea, 314
Prothonotary Warbler, 314, 336, 338
Psittacidae, 270
Psittaci, 270
Purple Finch, 291, 335, 337
Purple Gallinule, 246
Purple Martin, 307, 335, 338
Purple Sandpiper, 250
Pygopodes, 223

Q

Querquedula cyanoptera, 234
discors, 233
Quiscalus quiscula aeneus, 290

R

Rail Black, 246, 339
King, 245, 335, 337
Virginia, 245, 335, 337
Yellow, 246, 339
Ralli, 245
Rallidae, 245
Rallinae, 245
Rallus elegans, 245
virginianus, 245
Raptores, 259
Raven, 283, 338
Recurvirostra americana, 248
Recurvirostridae, 248
Red Phalarope, 247, 339
Red-backed Sandpiper, 251, 339
Red-bellied Woodpecker, 274, 336, 337
Red-breasted Merganser, 239, 339
Red-breasted Nuthatch, 329, 340
Red-eyed Vireo, 312, 336, 338
Redhead, 235, 335, 339
Red-headed Woodpecker, 273, 336, 337
Red-legged Black Duck, 232, 339
Redpoll, 291, 340
Red-shafted Flicker, 274, 337
Red-shouldered Hawk, 262, 337
Redstart, 324, 336
Red-tailed Hawk, 261, 335, 336, 337
Western, 262, 337
Red-winged Blackbird, 285, 335, 336, 338
Regulinae, 331
Regulus calendula calendula, 331
satrapa satrapa, 331
Rhynchophanes mccowni, 294
Richardson's Pigeon Hawk, 265
Ring-billed Gull, 225, 335, 339
Ring-necked Duck, 236, 339
Riparia riparia, 309
Rissa tridactyla tridactyla, 225
Robin, 333, 336, 338
Rose-breasted Grosbeak, 305, 336, 338
Rough-legged Hawk, 263, 337
Rough-winged Swallow, 310, 335, 338
Ruby-crowned Kinglet, 331, 335, 340
Ruby-throated Hummingbird, 277, 336, 337
Ruddy Duck, 238, 335, 339
Ruddy Turnstone, 256, 340
Ruffed Grouse, 257, 338
Rusty Blackbird, 289, 335, 337

S

Sanderling, 252, 340
Sandhill Crane, 244, 335, 339
Sandpiper, Baird's, 250, 335, 339
Buff-breasted, 254, 336, 340
Least, 251, 335, 339
Pectoral, 250, 335, 339
Purple, 250
Red-backed, 251, 339
Semipalmated, 251, 335, 340
Solitary, 253, 336, 340
Spotted, 254, 336, 337
Stilt, 249, 339
Western, 251, 340
White-rumped, 250, 339
Sapsucker, Yellow-bellied, 273, 335, 337
Sarcorhamphi, 259

Savannah Sparrow, 294, 335, 338
Western, 295
Saw-whet Owl, 268, 340
Sayornis phoebe, 279
Scarlet Tanager, 307, 336, 338
Scaup Duck, 235, 335, 339
Scolopacidae, 248
Scoter, 237, 339
Surf, 238, 339
White-winged, 238
Screech Owl, 268, 336, 337
Seiurus aurocapillus, 321
motacilla, 322
noveboracensis notabilis, 321
Semipalmated Plover, 256, 336, 340
Semipalmater Sandpiper, 251, 335, 340
Sennett's Nighthawk, 277, 340
Setochalcis vocifera vocifera, 275
Setophaga ruticilla, 324
Sharp-shinned Hawk, 260, 337
Short-billed Marsh Wren, 328, 335, 338
Short-eared Owl, 267, 337, 338
Shoveller, 234, 335, 338, 339
Shrike, Migrant, 311, 335, 337, 338
Northern, 311, 337
White-rumped, 311
Shufeldt's Junco, 301, 340
Sialia sialis sialis, 334
Siskin, Pine, 292, 335, 337
Sitta canadensis, 329
carolinensis carolinensis, 329
Sittidae, 329
Slate-colored Junco, 301, 337
Smith's Longspur, 293, 340
Snipe, Wilson's, 248, 335, 339
Snow Bunting, 293, 340
Snow Goose, 238, 335, 339
Snowy Egret, 243
Snowy Owl, 269, 340
Solitary Sandpiper, 253, 336, 340
Song Sparrow, 302, 335, 337, 338
Sora, 245, 335, 337
Sparrow, Baird's, 295, 340
Chipping, 299, 335, 338
Clay-colored, 300, 336, 340
English, 292, 336, 338
Field, 300, 335, 337, 338
Western, 300, 340
Fox, 303, 335, 337
Gambel's, 298, 337
Grasshopper, 295, 336, 338
Western, 296, 340
Harris's, 297, 335, 337
Henslow's, 296, 335, 338
Lark, 297, 336, 338
Leconte's, 296, 335, 340
Lincoln's, 302, 335, 337
Savannah, 294, 335, 338
Western, 295, 340
Song, 302, 335, 337, 338
Swamp, 303, 335, 337
Tree, 299, 337
Western, 299, 340
Vesper, 294, 335, 338
White-crowned, 298, 335, 337
White-throated, 298, 335, 340
Sparrow Hawk, 265, 336, 337
Spatula clypeata, 234
Speotyto cunicularia hypogaea, 269
Sphyrapicus varius varius, 273
Spinus pinus, 192
Spiza americana, 306
Spizella monticola monticola, 299
ochracea, 299
pallida, 300
passerina passerina, 299
pusilla arenacea, 300
pusilla, 300
Spotted Sandpiper, 254, 336, 337
Sprague's Pipit, 325, 340
Squatarola squatarola, 255
cynosurae, 255
Steganopodes, 228
Steganopos tricolor, 248
Stelgidopteryx serripennis, 309
Stercorariidae, 224
Stercorarius longicaudus, 225
parasiticus, 224
pomarinus, 224
Sterna antillarum, 227
caspia, 227
forsteri, 227
hirundo, 227
Sturnella magna magna, 288
neglecta, 288
Sterninae, 227

Sternula antillarum antillarum, 227
Stilt Sandpiper, 249, 339
Stringes, 266
Strigidae, 267
Strix varia varia, 268
Summer Tanager, 307, 336, 338
Surf Scoter, 238, 339
Swainson's Hawk, 263, 340
Swallow, Bank, 309, 336, 338
Barn, 308, 335, 338
Cliff, 308, 336, 338
Rough-winged, 309, 335, 338
Tree, 308, 336, 340
Swallow-tailed Kite, 259, 338, 340
Swamp Sparrow, 303, 335, 337
Swan, Trumpeter, 241, 339
Whistling, 241, 339
Swift, Chimney, 277, 335, 338
Sycamore Warbler, 320, 335, 339
Sylviidae, 331

T

Tanager, Scarlet, 307, 336, 338
Summer, 307, 336, 338
Tangaridae, 307
Teal, Blue-winged, 233, 337
Cinnamon, 234, 339
Green-winged, 233, 335, 337
Telmatodytes pulustris iliacus, 328
Tennessee Warbler, 316, 336, 340
Tern, Black, 228, 336, 337
Caspian, 227, 339
Common, 227, 336, 339
Forster's, 227, 336, 339
Least, 227, 336, 338, 339
Tetraonidae, 257
Thick-billed Red-wing, 286, 337
Thrasher, Brown, 326, 335, 338
Thrush, Gray-cheeked, 332, 336, 340
Hermit, 333, 335, 340
Olive-backed, 333, 336, 340
Willow, 332, 336
Wood, 332, 336, 338
Thryomanes bewicki bewicki, 327
Thryothorus ludovicianus ludovicianus, 327
Tringa canutus, 249
Titmouse, Tufted, 330, 336, 338
Totanus flavipes, 252
melanoleucus, 252
Towhee, 304, 335, 337, 338
Arctic, 304, 340
Toxostoma rufum, 326
Traill's Flycatcher, 281, 336, 339
Tree Sparrow, 299, 337
Western, 299
Tree Swallow, 308, 336, 340
Trochili, 277
Trochilidae, 277
Troglodytes aedon parkmani, 327
Troglodytidae, 327
Trumpeter Swan, 241, 339
Tryngites subruficollis, 254
Tufted Titmouse, 330, 336, 338
Turdidae, 332
Turninae, 332
Turkey Vulture, 259, 335, 337
Turkey, Wild, 258, 338
Turnstone, Ruddy, 256, 340
Tympanuchus americanus americanus, 257
Tyrannidae, 278
Tyrannus tyrannus, 278
verticalis, 278
Tyto alba pratincola, 266

U

Upland Plover, 253, 336, 338, 340

V

Vermivora, celata celata, 316
chrysoptera, 315
peregrina, 316
pinus, 315
rubricapilla rubricapilla, 315
Vesper Sparrow, 294, 335, 338
Vireo belli belli, 313
griseus griseus, 313
Vireo, Bell's, 313, 336, 338
Blue-headed, 313, 336, 340
Philadelphia, 312, 336, 340
Red-eyed, 312, 336, 338
Warbling, 312, 336, 338
White-eyed, 313, 336, 338
Yellow-throated, 312, 336, 338

Vireonidae, 312
Vireosylva gilva gilva, 312
olivacea, 312
philadelphica, 312
Virginia Rail, 245, 335, 337
Vulture, Turkey, 259, 335, 337

W

Warbler, Bay-breasted, 319, 340
Blackburnian, 319, 336, 340
Black-poll, 319, 336, 340
Black-throated Blue, 317
Black-throated Green, 320, 336, 340
Black and White, 314, 336, 338
Blue-winged, 315, 336, 338
Canada, 324, 340
Cape May, 317, 336, 340
Cerulean, 318, 336, 338
Chestnut-sided, 319, 336, 340
Connecticut, 322, 340
Golden-winged, 315, 340
Hooded, 324, 336, 338
Kentucky, 322, 336, 338
Magnolia, 318, 336, 340
Mourning, 323, 336, 340
Myrtle, 317, 335, 337
Nashville, 315, 336, 340
Northern Parula, 316, 336, 338
Orange-crowned, 316, 336, 340
Palm, 321, 336, 340
Pileolated, 324, 340
Pine, 320, 340
Prairie, 321, 340
Prothonotary, 314, 336, 238
Sycamore, 320, 335, 339
Tennessee, 316, 336, 340
Wilson's, 324, 336, 340
Worm-eating, 314, 336, 338
Yellow, 317, 336, 338
Warbling Vireo, 312, 336, 338
Water-Thrush, Grinnell's, 321, 336, 340
Louisiana, 322, 335, 338
Water-Turkey, 228
Waxwing, Bohemian, 309, 340
Cedar, 310, 337
Western Field Sparrow, 300, 340
Western Grasshopper Sparrow, 296, 340
Western Grebe, 223
Western Horned Owl, 269, 339
Western House Wren, 327, 335, 338
Western Meadowlark, 288, 338
Western Mourning Dove, 259
Western Nighthawk, 276, 340
Western Red-tail, 262, 337
Western Sandpiper, 251, 340
Western Savannah Sparrow, 295, 340
Western Tree Sparrow, 299, 340
Wistern Willet, 253, 340
Whip-poor-will, 275, 336, 338
Whistling Swan, 241, 339
White-breasted Nuthatch, 329, 336, 338
White-crowned Sparrow, 298, 335, 337
White-eyed Vireo, 313, 336, 338
White-faced Glossy Ibis, 241, 339
White-fronted Goose, 239, 335, 339
White Pelican, 229, 335, 339
White-rumped Sandpiper, 250, 339
White-rumped Shrike, 311
White-throated Sparrow, 298, 335, 340
White-winged Crossbill, 291, 340
White-winged Junco, 301, 340
White-winged Scoter, 238
Whooping Crane, 244, 339
Wild Turkey, 258, 338
Willet, 253, 340
Western, 253, 340
Willow Thrush, 332, 336, 340
Wilsonia canadensis, 324
citrina, 324
pusilla pileolata, 324
pusilla, 324
Wilson's Phalarope, 248, 336, 339
Wilson's Snipe, 248, 335, 339
Wilson's Warbler, 324, 336, 340
Winter Wren, 328, 337
Woodcock, 248, 338, 339
Wood Duck, 235, 338, 339
Woodpecker, Downy, 272, 336, 337
Hairy, 272, 336, 337
Ivory-billed, 272, 338
Northern Pileated, 273, 338
Red-bellied, 274, 336, 337
Red-headed, 273, 336, 337
Wood Pewee, 280, 336, 338
Wood Thrush, 332, 336, 338
Worm-eating Warbler, 314, 336, 338

Wren, Bewick's, 327
Carolina, 327, 336, 338
Prairie Marsh, 328, 335, 338
Short-billed Marsh, 328, 335, 338
Western House, 327, 335, 338
Winter, 328, 337

X

Xanthocephalus xanthocephalus, 284

Y

Yellow-bellied Flycatcher, 280, 336, 340
Yellow-bellied Sapsucker, 273, 335, 337
Yellow-billed Cuckoo, 270, 336, 337
Yellow-breasted Chat, 323, 336, 338
Yellow-crowned Night Heron, 243, 338
Yellow-headed Blackbird, 284, 335, 338
Yellow-legs, 252, 335, 340
Greater, 252, 335, 340
Yellow Rail, 246, 339
Yellow-throat, Maryland, 323, 336, 338
Yellow-throated Vireo, 312, 336, 338
Yellow Warbler, 317, 336, 338

Z

Zamelodia ludoviciana, 305
Zenaidura macroura carolinensis, 258
marginella, 259
Zonotrichia albicollis, 298
leucophrys gambeli, 298
leucophrys, 298
querula, 297

Issued February 27, 1919

Transactions of The Academy of Science of St. Louis.

VOL. XXIII. No. 9.

A STUDY OF THE PROPERTIES OF INTEGRAL NUMBERS.

NEW EVIDENCE OF A RELATION BETWEEN GRAVITATION AND ELECTRICAL ACTION AND OF LOCAL CHANGES IN THE ELECTRICAL POTENTIAL OF THE EARTH.

FRANCIS E. NIPHER.

Issued March 2, 1920.

A STUDY OF THE PROPERTIES OF INTEGRAL NUMBERS.*

FRANCIS E. NIPHER.

In the 1917 edition of A History of Elementary Mathematics, pp. 32–3, Cajori refers to the work of Nicomachus, who lived about A. D. 100, as follows:

"He gives the following important proposition: All cubical numbers are equal to the sum of consecutive odd numbers. Thus, $8 = 2^3 = 3 + 5$; $27 = 3^3 = 7 + 9 + 11$; $64 = 4^3 = 13 + 15 + 17 + 19$."

It seemed probable that such interesting relations did not end so abruptly as this statement might indicate, although information along this line seems to be lacking in modern text-books and mathematical dictionaries.

A series of consecutive numbers and likewise of consecutive even numbers yielded no results of this character.

It was found that a series of consecutive odd numbers from unity to any odd number y satifies the equation

$$1 + 3 + 5 + 7 + \ldots\ldots\ldots y = \left(\frac{1+y}{2}\right)^2 = N^2$$

where N is the number of terms in the series. The table of numbers here given shows the relation of these numbers. In Chrystals' Algebra, Vol. I, p. 467, it is stated that this proposition was known to the Greek geometers. It is stated as follows: "The sum of any number of consecutive odd integers beginning with unity is the square of their number." A table of squares furnished the necessary data for a study of the subject. It was at once apparent that any number x raised to any degree n where n is an even number could be represented as the sum of an arithmeti-

TABLE I.

y	v
1	
3	$4 = 2^2$
5	$9 = 3^2$
7	$16 = 4^2$
9	$25 = 5^2$
11	$36 = 6^2$

*Presented before the Academy of Science of St. Louis, Jan. 19, 1920.

cal series of consecutive odd numbers, the first term of which is unity and the final term of which is

$$l = 2x^{\frac{n}{2}} - 1 \qquad (1)$$

and that the number of terms in the series is

$$N = x^{\frac{n}{2}} \qquad (2)$$

The summation value is

$$\frac{1+l}{2} N = x^n = N^2 \qquad (3)$$

When n is an odd number, such a series will represent x^n if x is the square of some integral. The sum of a consecutive series of odd numbers from 1 to 15 is 64. The final term and the number of terms satisfy equations (1) and (2) above when $x = 8$ and $n = 2$, when $x = 2$ and $n = 6$, or when $x = 4$ and $n = 3$. The values of l and N can also be computed and yield the same results for 64^2, 8^4, 4^6, 2^{12}, and 16^3. Table II, adjoining, represents the series for $x = 2$ and 3 for various values n.

The result obtained by Nicomachus indicates that when n is an odd number the first term of the series of consecutive odd numbers which is to have a sum x^n should be greater than unity. The results in Table III were readily obtained by an inspection of the column of odd numbers and the summation of various groups of consecutive terms. The values of the first and last terms of the series were found to be

$$a = x^{\frac{n+1}{2}} - x^{\frac{n-1}{2}} + 1$$

$$l = x^{\frac{n+1}{2}} + x^{\frac{n-1}{2}} - 1 \qquad (4)$$

The number of terms in the series is

$$N = x^{\frac{n-1}{2}}. \qquad (5)$$

TABLE II.

x^n

$x=2$					$x=3$		
2^2	2^4	2^6	2^8	2^{10}	3^2	3^4	3^6
1	1	1	1	1	1	1	1
3	3	3	3	3	3	3	3
4	5	5	5	5	5	5	5
7	7	7	7	7	9	7	7
16	9	9	9	9		9	9
	11	11	11	11		11	11
	13	13	13	13		13	13
	15	15	15	15		15	15
	64	17	17	17		17	17
		19	19	19		81	19
		21	21	21			21
		23	23	23			23
		25	25	25			25
		27	27	27			27
		29	29	29			29
		31	31	31			31
		256	33	33			33
			35	35			35
			37	37			37
			39	39			39
			41	41			41
			43	43			43
			45	45			45
			47	47			47
			49	49			49
			51	51			51
			53	53			53
			55	729			
			57				
			59				
			61				
			63				
			1024				

A verification of these equations is shown in the fact that

$$\frac{a+l}{2}N = x^n. \qquad (3)$$

This is equation (3). From equation (5) we have

$$x^n = xN^2,$$

which, with equation (3), gives the result

$$\frac{a+l}{2} = xN. \qquad (6)$$

In the former case, where $a = 1$ and n is an even number, equation (3) gave

$$\frac{1+l}{2} = N.$$

Equation (5) may be readily obtained by inspection, after the results of Table III are obtained, and it is readily seen that the values of a and l in equations (4) may also be written

$$\begin{aligned} a &= Nx - N + 1 \\ l &= Nx + N - 1. \end{aligned} \qquad (7)$$

In Table IV the group of terms having a summation value 2^9 is reproduced, and the summation values from $a = 17$ to each succeeding term are given in the second column. In the third column the first factor is the number of terms that have been added from and including $a = 17$ to the various succeeding terms, and the second factor is the average value of the first term, 17, and subsequent terms. The result reached in Eq. (6) is shown in the final term of the series, where the final term l is 47.

For any value of x the number of terms in the series when n is an even number, is the same as in the series for the same value of x when n is an odd number and one unit greater in value. Table V gives the numerical values for the quantities represented in the above equations for $x = 2$ and $x = 3$ for values of n from 2 to 13.

It may be pointed out that when x is the square of

TABLE III.

x^n

$x=2$				$x=3$			
2^3	2^5	2^7	2^9	3^3	3^5	3^7	
3							
5	5						
8	7			7			
	9	9		9			
	11	11		11			
	32	13		27			
		15					
		17	17				
		19	19		19		
		21	21		21		
		23	23		23		
		128	25		25		
			27		27		
			29		29		
			31		31		
			33		33		
			35		35		
			37		243		
			39				
			41				
			43				
			45				
			47				
			512				
						55	
						57	
						..	
						..	
						..	
						..	
						107	
						2187	

TABLE IV.

$$x^n = 2^9 \qquad a = 17$$

l	$s = N\frac{a+l}{2}$
19	$36 = 2 \times 18$
21	$57 = 3 \times 19$
23	$80 = 4 \times 20$
25	$105 = 5 \times 21$
27	$132 = 6 \times 22$
29	$161 = 7 \times 23$
31	$192 = 8 \times 24$
33	$225 = 9 \times 25$
35	$260 = 10 \times 26$
37	$297 = 11 \times 27$
39	$336 = 12 \times 28$
41	$377 = 13 \times 29$
43	$420 = 14 \times 30$
45	$465 = 15 \times 31$
47	$512 = 16 \times 32 = 2^9$

some integral number, the value of x^n may be represented by either of the systems above described. For example of $x = 25$ and $n = 2$ and the first term of the series be taken as unity, the final term will be

$$l = 2 \times 25^{\frac{2}{2}} - 1 = 49.$$

The sum of the series will be 625. The number of terms will be 25. The sum of the series is equal to the square of the number of terms, as is shown in Eq. (3).

If the second method above discussed be adopted, equations (4) give as the first and last terms

$$a = 25^{\frac{3}{2}} - 25^{\frac{1}{2}} + 1 = 121$$

$$l = 25^{\frac{3}{2}} + 25^{\frac{1}{2}} - 1 = 129$$

The number of terms will then be

$$N = 25^{\frac{2-1}{2}} = 5.$$

The sum of the series, or 625, will then be x times the square of the number of terms, as is shown in the former discussion.

Any number which is in the second column of Table I can be thus treated.

TABLE V.

	$x=2$				$x=3$			
n	x^n	N	a	l	x^n	N	a	l
2	4	2	1	3	9	3	1	5
3	8	2	3	5	27	3	7	11
4	16	4	1	7	81	9	1	17
5	32	4	5	11	243	9	19	35
6	64	8	1	15	729	27	1	53
7	128	8	9	23	2,187	27	55	107
8	256	16	1	31	6,561	81	1	161
9	512	16	17	47	19,683	81	163	323
10	1,024	32	1	63	59,049	243	1	485
11	2,048	32	33	95	177,147	243	487	971
12	4,096	64	1	127	531,441	729	1	1457
13	8,192	64	65	191	1,594,323	729	1459	2915

The series having a sum 3^3 appears in Table V as computed from equations (4). The first and last terms are $a=3$ and $l=7$. This is one of the results of Nicomachus.

It is therefore apparent that any integral number raised to any power can be represented as the sum of a consecutive series of odd numbers.

In the discussion which followed the presentation of this paper, Dr. C. H. Danforth suggested that the numerical values represented in Table I might be represented graphically, as is done in the diagrams at the top of Fig. 1. Starting with a small square at the upper left-hand corner, having unit area, a series of equal squares representing consecutive odd numbers are added in the three diagrams on the right. The added areas are in each

case marked by small dots in the middle. The resulting areas are 2^2, 3^2, and 4^2. This may be the way in which the Greek geometers arrived at the results in Table I of this paper.

If the area marked 2^2 in Fig. 1 is multiplied by 2, the resulting area will be half the area of the square marked 4^2, or 2^4. If this area is again multiplied by 2, the resulting area will be equal to that of the square marked 4^2. It will be 2^4. It has long been known that $2^4 = 4^2$. At the bottom of this plate is a square area, having within it a rectangular area whose sides have a length 4 and 1. If this area be multiplied by 4, the resulting area will fill the lower left-hand quarter of the square. The resulting area will be 4^2. If this area be again multiplied by 4, the resulting area will be 4^3. If we start with the lower half of the rectangular area having sides 2 and 1, and multiply this area by 2, the resulting area will have sides 1 and 4. Its area will be 2^2. Multiplying again by 2, the resulting area will be one-half the area of the square in the lower left-hand corner of this diagram, or 2^3. Continuing the operation we shall find that the area of the square marked 4^3 is also 2^6. By reference to the diagram above it will appear that the resulting area is also 8^2.

Small cubes, the six faces of each having unit area, may be placed on the 64 squares in the two lower diagrams of Fig. 1. The volume upon each large square will be 8^2 units. If the cubes resting on the 48 unit areas in the two upper quarters and the lower right quarter of the large squares be superposed on the other quarter, the volumes of the two cubes resulting will be 4^3.

Added Feb. 25, 1920.

It will be observed that if the numeral 1 be dropped from the exponents in Eqs. (4) and (5), these equations become equations (1) and (2), the value a becoming unity.

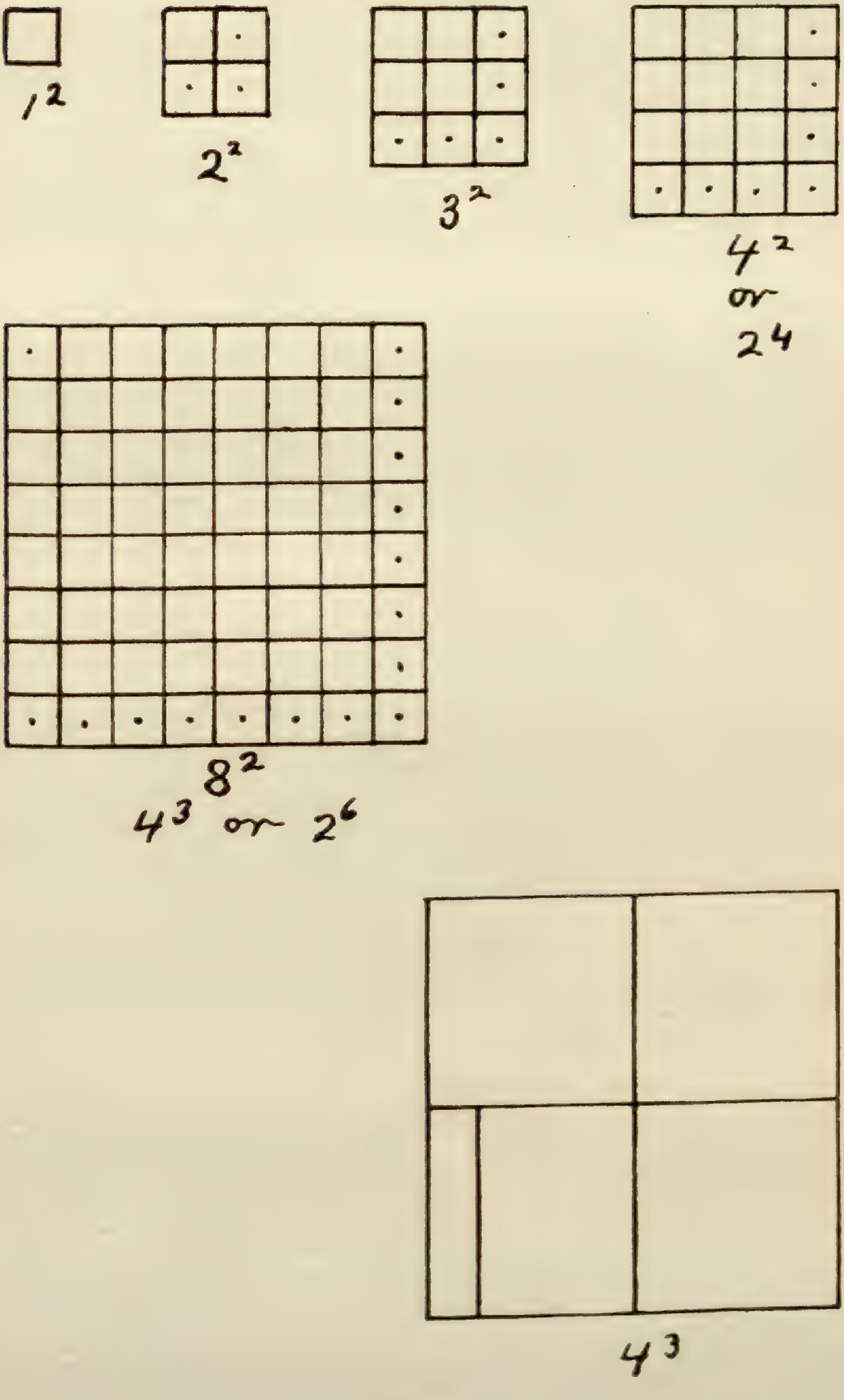


Fig. 1.

NEW EVIDENCE OF A RELATION BETWEEN GRAVITATION AND ELECTRICAL ACTION, AND OF LOCAL CHANGES IN THE ELECTRICAL POTENTIAL OF THE EARTH.*

FRANCIS E. NIPHER.

In the work to be here described, the apparatus used was a modified form of that used by Cavendish, as shown in the former paper, published by the Academy of Science of St. Louis, Vol. XXIII, pp. 183-4-5.

The wood frame was in this case covered with tin-foil, within and without. The sheet metal forming the sides of the shield were clamped to the wood frame, by bars of wood which were also covered with tin-foil. All joints were sealed with wax before the tin-foil was put in place. The whole shield was then surrounded by two end caps of metal which meet at the middle of the shield and are sealed together by means of tin-foil. A layer of air was thus formed between the two metal shields surrounding the suspended masses. Either of these two metal shields was considered ample protection to prevent the suspended masses from being acted upon electrically by the large masses. The layer of air between the two shields was designed to diminish convection effects within the shield due to changes in the temperature of the room, and changes in the temperature of the air within the room were made as small as possible, by cutting off all sources of artificial heat. It did not usually vary more than 1.5 degrees C. during the day. The temperature was determined by means of a thermometer placed near the large masses. The reading was by means of a telescope. The reading could be made accurately to tenths of a degree C. and hundredths of a degree could be estimated with fair precision. The air within the shield was

electrically charged by means of a wire armed with a pin which was thrust through a glass tube which was thrust through the end of the shield about an inch above the level of the suspended masses, and was sealed in place. The inner end of the tube was drawn to a small diameter, being only large enough to admit the end of the pin. This could be withdrawn at any time and the outer end of the tube could be covered with a metal tube which was closed with a metal plug at its outer end.

Convection effects, due to changes in temperature, have been very carefully studied. When the masses have not been electrically charged for several days, the rise in the temperature of the room during the day caused a very slow increase in the scale reading which determined the position of the suspended masses. This change in position decreases the distance between the suspended masses and the large masses. When a door opening into the hallway was opened for four minutes this change is larger and more abrupt. When an outside window was opened, admitting cold air, a sudden decrease in the reading results.

The room containing the apparatus was always entered from an adjoining room, from which heat from the heating system was wholly cut off.

In order to decrease convection effects, the large masses and shield were covered on all sides with a pile of cotton batting, forming a layer of about six to eight inches in thickness. This was permissible by reason of the fact that the electric machine in the adjoining room was discarded as a source of electricity. It was replaced by the earth, which had been found to be equally effective, and which has a much greater capacity. The large masses and shield, and when necessary, the injection pin were connected by wire with a copper lightning rod on the outside of the building. This rod formed the ground connection for a steel tower used for wireless. Its top was one hundred feet above the ground. This tower is mounted upon the roof of the physics building, the walls

of which are of red granite. The room containing the apparatus is in the second story of this building, and below this tower.

Twelve copper wires about ten feet in length were soldered to the lower part of the lightning rod, and spread over the ground, their ends being injected a few inches into the soil. The wire leading from the masses within the building to the rod was also soldered to it. Connected with this wire within the room containing the gravitating masses were metal rods surrounding the apparatus on which were hung sheets of metal to which were attached about one thousand pins. Small holes were punched through the metal, the pins were inserted, and the heads were soldered to the metal. This was intended as a means to put all of the air in the room in an electrical condition as near uniform as possible.

With such an apparatus a determination of the gravitation constant would be utterly impossible. The position of the suspended masses changes from day to day and from night to day by greater amounts than was at any time possible when the plate-glass machine was used for electrification of the masses. Their position depends upon the weather and upon the moisture in the surface of the earth. The changes were often greater than was ever caused by the removal or replacing of the large masses. Results obtained on December 12th last are alone sufficient to establish the fact that enormous local changes in the earth's potential are constantly occurring, and that these changes produce variations in gravitational attraction between the large masses and the suspended masses.

On December 5th and 6th over an inch of rain and sleet fell, and on December 8th and 9th there was a light fall of sleet. The minimum temperature gradually fell from 28° on the 5th to 1° on the 10th. The ground was covered with a thin layer of ice and snow on the 12th. On that day the morning temperature was 20° but rose to 56°. The ground around the lightning rod between the build-

ing and a walk about 12 feet from the building was very dry, having been shielded by the building. During the forenoon the large masses and the injection pin for electrification of the air within the shield were connected with the lightning rod. Between 8:50 a. m. and 11:45 p. m. the scale reading decreased very slightly but with no vibrations. The temperature of the air around the shield increased by 1.°5 C. The injection pin was then withdrawn and the glass tube was covered with the metal cap. Vibrations of the suspended masses at once began. The scale reading varied through about three divisions of the scale. This amplitude had diminished to about two divisions of the scale at 1:20 p. m. The time of a complete vibration was about nine minutes. The frozen ground outside of the walk was then covered with a layer of water. Eight buckets of water were splashed over the ground around the lightning rod, covering the area over which the copper wires were spread, this wet area thus formed being finally connected with the wet ground beyond the walk. The scale reading abruptly diminished during the next three vibrations. The change in the average reading was about 80 per cent of the change formerly produced by the removal of the large masses to a position of no deviation in the position of the suspended masses.

This determination of the deviation, due to the large masses, was obtained before electrification of the masses was begun. They were, however, then above the surface of the earth, and subject to the inductive action of the atmosphere.

The results described in this paper indicate that the disturbances here discussed would be greatest if the work were done on a barren island, in a building above the level of the surrounding water. It is under such conditions that the phenomenon known as St. Elmo's fire is commonly observed. On land each blade of grass and the leaves of trees have a function similar to that of the masts of ships provided with lightning protection. They are

individually less effective, but they are far more numerous.

In order to eliminate these disturbing effects the work should be done in a room below the surface of the earth, the walls, ceiling and floor being of metal. Insulated copper wires within copper tubes should be connected with the masses. Those connected with the suspended masses should terminate in a cup of mercury. A flexible chain of metal attached to the middle of the bar carrying the suspended masses, should be provided at its lower end with a fine platinum wire, making contact with the mercury surface. These protected copper wires should be grounded in a well of water. The water in this well must be protected from any inductive action of the atmosphere.

The continuation of this work has been made possible by the financial assistance, formerly acknowledged, of the Carnegie Institution of Washington, and by the granting of every needed facility by Washington University.

Issued March 2 1920.